

FROM COLLECTIVE IDENTITY TO INDIVIDUAL ACTION: THE LOGIC BEHIND UNIVERSITY STUDENTS STUDYING IN THAILAND' CARBON REDUCTION BEHAVIOR

Yuxuan Wan

An Independent Study submitted in partial fulfillment of the Requirements for the Degree of Master of Management Program in Creative Industries Management
Rattanakosin International College of Creative Entrepreneurship
Rajamangala University of Technology Rattanakosin
Academic Year 2026
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ABSTRACT

The objectives of this research were (1) to examine the effects of attitude, subjective norms, and perceived behavioral control on carbon reduction behavior among Thai university students, (2) to investigate the influence of collective identity on carbon reduction behavior, and (3) to analyze the mediating role of collective identity between the Theory of Planned Behavior (TPB) variables and carbon reduction behavior.

This research employed a questionnaire survey among Thai university students in Bangkok. The study collected data from 347 valid respondents through a structured questionnaire using a seven-point Likert scale. The collected data were analyzed using computer software and structural equation modeling. The data analysis included descriptive statistics, reliability analysis, confirmatory factor analysis (CFA), structural equation modeling (SEM), and bootstrap mediation analysis.

Major Findings/Results: (1) The results indicated that attitude, subjective norms, and perceived behavioral control significantly and positively influenced carbon reduction behavior, confirming the applicability of the Theory of Planned Behavior in explaining students' environmental actions; (2) Collective identity had a significant positive effect on carbon reduction behavior, demonstrating that students' sense of belonging and shared environmental responsibility could promote individual low-carbon actions; and (3) Collective identity significantly mediated the relationships between attitude, subjective norms, perceived behavioral control, and carbon reduction behavior, suggesting that psychological identification with an environmentally responsible group serves as an important mechanism transforming personal beliefs into actual environmental practices.

Keywords: Carbon reduction behavior, Theory of planned behavior, Collective identity, University students, Environmental behavior

Advisor's Signature: .....

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May all those I love and who love me be blessed with health, peace, and all the beautiful things life has to offer.

Yuxuan Wan

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CHAPTER 1
INTRODUCTION

1.1 Research Background

The global warming phenomenon has emerged as one of the most severe ecological threats confronting humanity presently. Fossil fuel combustion, especially the release of carbon dioxide, is viewed as the main factor driving planetary heating. Per the Intergovernmental Panel on Climate Change (IPCC), international carbon discharges have persisted in rising throughout recent years, rendering decarbonization an essential approach for reducing climatic shifts. To address this issue, numerous nations and territories have formulated long-range discharge-cutting targets, such as the EU's carbon goals and China's net-zero pledge (IPCC, 2021). Nevertheless, realizing worldwide climate targets demands not merely technical advancement and policy enforcement at political and corporate tiers but also lifestyle modifications among people.

Against this background, carbon reduction behavior has become an important research topic in environmental psychology and sustainability studies. Carbon reduction behavior involves various daily practices, including energy conservation, low-carbon transportation, waste reduction, and green consumption. Previous studies have demonstrated that individual carbon reduction behavior is influenced not only by environmental knowledge and personal attitudes but also by social norms, perceived behavioral control, and group-related psychological factors (Steg & Vlek, 2009). Therefore, understanding the psychological and social mechanisms underlying individual carbon reduction behavior is essential for developing effective behavioral interventions, particularly among university students who represent an important group for future sustainable development.

As a major developing country in Southeast Asia, Thailand has experienced rapid economic and social development in recent decades. However, economic growth, urbanization, and increasing energy consumption have also contributed to rising carbon emissions. According to the International Energy Agency (2020), the energy and

transportation sectors remain major sources of carbon emissions in Thailand. In response to climate challenges, the Thai government and higher education institutions have increasingly promoted environmental sustainability initiatives, including green campus development and environmental education programs.

Background of Carbon Reduction Behavior among University Students in Thailand

As a major developing country in Southeast Asia, Thailand has achieved significant socio-economic development over the past several decades. However, rapid economic growth has also increased energy consumption and carbon emissions. According to the International Energy Agency (2020), the energy and transportation sectors are among the major contributors to Thailand's carbon emissions, largely due to industrial development, urbanization, and the expansion of transportation systems. In this context, universities have become important platforms for promoting sustainable development and cultivating environmentally responsible behaviors among young adults. University students in Thailand, including both domestic and international students studying in Thai higher education institutions, represent an important group in advancing carbon reduction practices through individual behavioral changes and collective environmental actions.

Although the Thai government and higher education institutions have implemented various initiatives, such as environmental education, green campus development, and sustainability campaigns, the adoption of carbon reduction behaviors among university students remains insufficient, and the transformation of environmental awareness into actual behavior is still limited (Vantamay, 2018). Therefore, understanding the factors that encourage university students in Thailand to engage in carbon reduction behavior has become an important research issue.

Carbon reduction behavior among university students in Thailand is influenced by multiple psychological and social factors. Although many students express concern about environmental problems, their engagement in low-carbon practices has not yet reached a consistent and deeply internalized level. Previous studies have demonstrated that environmental behaviors among young adults are affected not only by individual perceptions but also by social identity, group norms, and peer influence (Fielding & Hornsey, 2016). Particularly in Thailand, where collectivistic cultural values remain influential, individuals' behaviors are often shaped by social expectations, group belonging,

and shared values. Consequently, carbon reduction behavior may emerge not only from personal environmental awareness but also from individuals' identification with social groups and their willingness to act consistently with collective environmental goals (Maichum et al., 2016).

The socio-psychological mechanisms of carbon reduction behavior

Carbon mitigation actions are not merely outcomes of personal logical choices but are also significantly shaped by contextual and socio-psychological variables. Within ecological behavior studies, the Theory of Planned Behavior (TPB) is extensively applied to clarify people's behavioral purposes and ultimate conduct while encountering ecological choices. TPB suggests that a person's behavioral goals are influenced by three fundamental elements: behavioral attitude (favorable or unfavorable judgment of the action), subjective norms (community's anticipations regarding the action), and perceived behavioral control (a person's self-assurance concerning their personal operational skills) (Ajzen, 1991). Nevertheless, the constraint of TPB lies in its main emphasis on personal decision-making, overlooking the deep impact of socio-psychological elements like collective identity on actions.

"Identity" is a core concept in social identity theory. This theory emphasizes that an individual's self-concept and behavioral decisions are not solely derived from personal beliefs, but are closely linked to the values and behavioral norms of the group to which the individual belongs (Tajfel & Turner, 1979). In collectivist cultures, individual behavior is often driven by group identity and expectations; this phenomenon is particularly evident among university students—who view low-carbon behavior as "an identity label we should all practice," enabling individuals to validate and solidify their group identity through their actions. This social identity mechanism makes collective identity an important variable in research on carbon reduction behavior (Fritsche et al., 2018).

1.2 Significance of the Research

1.2.1 Theoretical Significance

(1) Integrating the Theory of Planned Behavior and Collective Identity Perspective

Ajzen's (1991) Theory of Planned Behavior (TPB) has been extensively utilized to elucidate personal ecological activities by highlighting the impacts of behavioral attitudes,

subjective norms, and perceived control over behavior. Former research has shown the utility of TPB in forecasting diverse pro-environmental actions (Bamberg & Möser, 2007). Nevertheless, current TPB-centered investigations regarding environmental conduct primarily concentrate on private cognitive elements and logical choice-making procedures, whereas the impact of collective-level psychological dynamics remains comparatively understudied. Specifically, TPB offers minimal clarification regarding how persons internalize communal anticipations and convert collective-oriented ideals into individual ecological initiatives.

To overcome this constraint, the current research incorporates collective identity derived from Social Identity Theory (Tajfel & Turner, 1979) into the TPB model and investigates its mediating function between TPB variables and carbon reduction actions. By recognizing collective identity as a psychological process that links personal cognition with behavioral results, this work offers a more holistic interpretation of how carbon reduction activities are developed within a social environment.

(2) Clarifying the Mechanism of Collective Identity in Carbon Reduction Behavior

Group-based identity highlights how people establish a feeling of connection and personal identity via their participation in communal units, which then impacts their opinions and conduct (Tajfel & Turner, 1979). Prior ecological conduct research has underscored the significance of societal identity, collective standards, and shared involvement in encouraging eco-friendly practices (Fielding & Hornsey, 2016; Fritsche et al., 2018). Nevertheless, current investigations have primarily analyzed the immediate link between social identity and ecological behavior, whereas the process by which collective identity transforms personal views into genuine practical activity stays inadequately investigated.

This research enriches existing academic work by investigating the mediating function of collective identity concerning behavioral attitudes, subjective norms, perceived behavioral control, and carbon mitigation actions. The results offer empirical proof concerning how personal psychological perspectives are translated into specific low-carbon practices via group identification mechanisms.

(3) Extending Environmental Behavior Research in the Context of Thai Higher Education

Previous environmental behavior studies have predominantly focused on Western contexts, while empirical evidence from Southeast Asian higher education environments remains relatively limited. Thailand provides an important research context because universities in Thailand involve diverse student populations and operate within a cultural environment where social relationships and collective values play important roles.

By examining university students studying in Thailand, including both domestic and international students, this study provides empirical evidence regarding the formation mechanism of carbon reduction behavior within a non-Western higher education context. The research extends existing environmental behavior studies by demonstrating how individual cognitive factors and collective psychological mechanisms jointly influence low-carbon actions in the Thai university environment.

1.2.2 Practical Significance

(1) Providing Practical Guidance for Low-Carbon Education Programs in Universities

University students represent an important group for promoting sustainable lifestyles because their daily behaviors can influence the development of long-term environmental practices. However, existing low-carbon education programs often emphasize environmental knowledge transmission, while paying insufficient attention to how students' psychological perceptions and social relationships influence behavioral adoption.

Based on the findings of this study, universities in Thailand can design more targeted low-carbon education programs by addressing students' attitudes, social influences, and perceived behavioral control. For example, universities can incorporate carbon reduction topics into environmental education courses, organize carbon reduction workshops, and provide real-life examples of how individual actions contribute to environmental improvement. These activities can strengthen students' positive attitudes toward carbon reduction behavior and increase their willingness to participate.

(2) Developing Campus-Based Collective Identity and Social Norm Interventions

The findings of this study highlight the importance of collective identity in promoting carbon reduction behavior. Therefore, universities can encourage low-carbon practices by creating a supportive campus culture and strengthening students' identification with environmental goals.

Specifically, universities may establish student environmental clubs, organize campus-wide carbon reduction campaigns, develop green volunteer programs, and implement group-based sustainability challenges. For example, students can participate in activities such as reducing single-use plastic consumption, promoting recycling practices, saving electricity in dormitories, and using public transportation or shared transportation options. Through collective participation and peer interaction, environmentally responsible behaviors can gradually become shared campus norms.

(3) Improving Students' Ability to Engage in Carbon Reduction Practices

Although students may have positive environmental attitudes, difficulties in implementation can prevent them from adopting consistent carbon reduction behaviors. Therefore, universities should provide practical conditions that enhance students' perceived behavioral control.

For instance, universities can improve recycling facilities, increase access to sustainable transportation options, promote energy-saving systems in classrooms and dormitories, and provide clear guidelines for daily low-carbon practices. By reducing practical barriers and increasing students' confidence in performing carbon reduction behaviors, universities can facilitate the transformation from environmental intention into actual behavior.

1.3 Research Questions and Objectives

1.3.1 Research Question

The primary goal of this research is to investigate the function and process of shared identity regarding the development of carbon-cutting conduct among college students residing in Thailand, particularly how collective identity impacts personal sustainable actions via TPB frameworks including behavioral attitudes, subjective norms, and perceived behavioral control. Consequently, the particular inquiry questions are as follows:

RQ1: Which factors—attitude toward behavior, perceived social pressure, and perceived capability—shape carbon emission mitigation actions by undergraduates attending Thai universities?

RQ2: In what manner does shared identity facilitate carbon emission reduction practices among college students residing in Thailand?

RQ3: In what manner does collective identity moderate the associations among behavioral attitude, subjective norms, perceived behavioral control, and carbon reduction actions among university students residing in Thailand?

1.3.2 Research Objectives

To address the aforementioned research inquiries, the primary goals of this investigation are as follows:

O1: To examine the impacts of behavioral intention, subjective norm, and perceived behavioral control on Thai university students' participation in carbon mitigation activities through the lens of the Theory of Planned Behavior, aiming to pinpoint the primary psychological factors influencing this conduct.

Objective 2: To examine the influence of shared identity on Thai university learners' efforts toward carbon mitigation by integrating the framework of social identity, thereby clarifying how collective-based psychological affiliation enhances personal sustainable conduct.

O3: To examine the mediating role of collective identity regarding behavioral attitude, subjective norm, perceived behavioral control, and carbon reduction behavior through path analysis, thereby disclosing how TPB-related cognitive elements are translated into tangible behavioral results via group identity.

1.3.3 Summary

This part defines the inquiry targets and aims of this investigation and establishes the groundwork for following research architecture and theoretical verification. The inquiry issues center on the three primary components of the TPB framework and the function of communal identity, emphasizing how personal conduct is shaped by group belonging and its intermediary position inside the TPB paradigm. The research goals specify the practical orientation of this research, employing quantitative evaluation to uncover how behavioral orientations, normative pressures, perceived control factors, and collective identity collectively affect the development of carbon mitigation actions.

1.4 Limitations of the study

1.4.1 Limitations of Sample Representativeness

This study investigated carbon reduction behavior among university students studying in Thailand. Although the sample was collected from students enrolled in Thai higher education institutions, the proportion of domestic and international students was not fully balanced. Among the 347 valid respondents, international students accounted for 59.9%, while Thai domestic students accounted for 40.1%. Although both groups shared similar educational environments and campus contexts, differences in cultural background, environmental experiences, and social norms may influence students' perceptions and carbon reduction behaviors.

Therefore, the findings should be interpreted as reflecting carbon reduction behavior among university students in the Thai higher education context rather than being generalized exclusively to Thai nationals. In addition, the role of collective identity in influencing environmental behavior may vary across different cultural groups. Future research could employ stratified or quota sampling methods to achieve a more balanced representation of Thai and international students and further examine cultural differences in carbon reduction behavior.

1.4.2 Diversity and Cross-Dimensional Characteristics of Carbon Reduction Behavior

Carbon reduction behavior is a multidimensional behavioral system involving various daily practices, including energy conservation, low-carbon transportation, waste reduction, and green consumption. This study operationalized carbon reduction behavior through several behavioral indicators to provide a comprehensive understanding of students' low-carbon practices. However, different types of carbon reduction behaviors may involve different psychological motivations, social influences, and practical constraints.

For example, energy-saving behaviors may depend more on individual habits and environmental awareness, while transportation choices may be influenced by infrastructure availability and social conditions. Therefore, future research could further examine the differences among various dimensions of carbon reduction behavior and explore how different behavioral types interact with psychological and social factors.

1.4.3 Cultural Adaptability and Measurement Limitations of the Scale

This study adopted measurement scales developed from previous research on the Theory of Planned Behavior and collective identity. Although the scales were reviewed and adjusted to fit the Thai higher education context, cultural differences may still influence respondents' understanding of certain items and their response patterns.

In particular, concepts such as collective identity, social norms, and environmental responsibility may have different meanings across cultural groups. Therefore, potential measurement differences may exist among Thai domestic students and international students. Future research should further validate the measurement instruments across different cultural groups and conduct comparative analyses to improve the cross-cultural applicability of the scales.

CHAPTER 2
LITERATURE REVIEW AND THEORETICAL FOUNDATION

2.1 Carbon Reduction Behavior

2.1.1 Definition and Concept of Carbon Reduction Behavior

Carbon reduction behavior refers to individual or collective actions that aim to reduce greenhouse gas emissions by changing patterns of energy use, transportation, consumption, and other daily activities (Stern, 2000). Unlike technological approaches that mainly depend on industrial transformation and governmental policies, carbon reduction behavior emphasizes the role of individuals in mitigating climate change through behavioral changes in everyday life. As climate change has become an increasingly urgent global challenge, individual behavioral transformation has been recognized as an essential component of achieving long-term emission reduction goals (Intergovernmental Panel on Climate Change [IPCC], 2022).

Within the field of ecological behavior studies, carbon mitigation actions are typically viewed as a particular manifestation of pro-nature behavior. Pro-nature behavior denotes broadly initiatives that lessen adverse ecological effects or promote conservation efforts, while carbon mitigation activities specifically concentrate on activities which either immediately or indirectly decrease greenhouse gas discharges (Steg & Vlek, 2009). Therefore, carbon reduction behavior represents a more targeted behavioral category within the broader field of environmental sustainability, emphasizing the relationship between individual actions and climate change mitigation.

According to Stern (2000), environmentally significant behavior can be understood based on the extent to which individual actions influence environmental outcomes. Carbon reduction behavior is considered environmentally significant because although individual actions may appear relatively small, aggregated behavioral changes among large populations can produce substantial reductions in energy demand and carbon emissions.

For example, reducing unnecessary electricity consumption, choosing public transportation instead of private vehicles, reducing disposable product use, and purchasing environmentally friendly products are all behaviors that contribute to carbon emission reduction.

Furthermore, carbon reduction behavior is not merely a temporary behavioral choice but represents a continuous process involving lifestyle adjustment and behavioral maintenance. Individuals may need to repeatedly make decisions regarding energy consumption, mobility, and purchasing practices in their daily lives. Therefore, carbon reduction behavior involves not only awareness of environmental problems but also the ability to translate environmental values into consistent behavioral practices (Steg & Vlek, 2009).

In the context of university students, carbon reduction behavior is particularly important because students are at a stage where personal values, lifestyles, and social behaviors are continuously developing. Their daily activities, including electricity use in dormitories, transportation choices, waste management, and consumption patterns, directly influence their carbon footprint. At the same time, students represent future social actors whose environmental behaviors may influence broader sustainability practices through social interaction and behavioral demonstration (Steg & Vlek, 2009). Therefore, university students provide an appropriate population for examining the psychological and social mechanisms underlying carbon reduction behavior.

2.1.2 Dimensions and Measurement of Carbon Reduction Behavior

Carbon reduction behavior is a multidimensional concept because carbon emissions are generated through various aspects of human activities. Previous environmental behavior studies suggest that individual carbon emissions are closely associated with energy consumption, transportation choices, and consumption patterns; therefore, these areas are commonly considered important dimensions for measuring carbon reduction behavior (Steg & Vlek, 2009).

The first dimension is energy conservation behavior. Energy conservation behavior refers to actions aimed at reducing unnecessary energy consumption in daily activities. Examples include turning off unused lights and electronic devices, reducing electricity consumption, and adopting energy-saving practices in homes, dormitories, or workplaces. Energy-related behaviors are particularly important because energy production and

consumption represent major sources of carbon emissions globally (IPCC, 2022). Among university students, energy conservation behavior can be reflected through daily practices such as saving electricity in dormitories, reducing excessive use of electronic equipment, and participating in campus energy-saving initiatives.

The second dimension is low-carbon transportation behavior. Transportation activities contribute significantly to carbon emissions, making mobility choices an important aspect of individual carbon reduction behavior. Low-carbon transportation behavior includes choosing public transportation, walking, cycling, reducing unnecessary travel, and avoiding high-carbon transportation options when possible (Steg & Vlek, 2009). For university students, transportation decisions are closely related to campus accessibility, living arrangements, and available transportation facilities. Therefore, students' transportation choices represent an important behavioral indicator of their commitment to carbon reduction.

The third dimension is green consumption and waste reduction behavior. This dimension involves environmentally responsible decisions during purchasing, consumption, and waste disposal processes. Examples include purchasing environmentally friendly products, reducing single-use plastics, recycling waste, and avoiding unnecessary consumption. Consumption-related behaviors are important because carbon emissions are not only produced during direct energy use but also throughout product production, transportation, and disposal processes (Stern, 2000).

Although energy conservation, low-carbon transportation, and green consumption represent different behavioral domains, they are interconnected components of carbon reduction behavior. Individuals who frequently engage in one type of environmentally responsible behavior may be more likely to adopt other sustainable practices because of behavioral consistency and environmental value reinforcement (Truelove et al., 2014). Therefore, examining carbon reduction behavior as a multidimensional construct provides a more comprehensive understanding of individuals' low-carbon practices.

2.1.3 Formation Characteristics of Carbon Reduction Behavior

Even though ecological consciousness serves as a vital basis for carbon mitigation activities, prior research has indicated that awareness alone frequently fails to produce genuine conduct involvement. A primary obstacle within sustainability behavior inquiry involves the divergence between ecological worry and real-world actions. People might

acknowledge the significance of climate shift reduction yet nonetheless struggle to implement steady carbon-cutting habits due to psychological hurdles, social pressures, or functional constraints (Kollmuss & Agyeman, 2002).

Carbon reduction behavior therefore represents a complex behavioral formation process rather than a simple outcome of environmental knowledge. Individuals need to transform abstract environmental values into concrete daily actions, such as reducing electricity consumption, selecting sustainable transportation methods, or changing consumption habits. This transformation involves the interaction between individual perceptions, social environments, and behavioral conditions (Steg & Vlek, 2009).

Another important characteristic of carbon reduction behavior is its dependence on daily context. Unlike behaviors that occur only occasionally, carbon reduction behaviors are embedded in routine activities and require continuous decision-making. For example, students repeatedly decide whether to save electricity, whether to use environmentally friendly products, and whether to select low-carbon transportation options. Therefore, the stability of carbon reduction behavior depends not only on whether individuals support environmental protection but also on whether such behaviors can become part of their regular lifestyle.

Moreover, carbon reduction behavior has both individual and social characteristics. At the individual level, personal values, environmental perceptions, and behavioral capability influence whether individuals are willing and able to perform low-carbon actions. At the social level, interpersonal relationships, institutional environments, and shared behavioral expectations may influence how individuals understand and maintain carbon reduction practices. Past studies have indicated that ecological conduct is influenced by the synergy between private incentives and communal settings instead of being determined solely by personal traits (Bamberg & Möser, 2007).

For university students, this process is particularly significant because campuses provide a highly interactive social environment. Students experience environmental education, peer communication, student organizations, and institutional sustainability programs during their university life. These experiences may influence how students understand carbon reduction behavior and whether they incorporate such behaviors into their daily routines. Therefore, examining university students' carbon reduction behavior requires consideration of both personal and social mechanisms.

2.1.4 Carbon Reduction Behavior among University Students in Thailand

University students represent an important group in sustainability research because they are future decision-makers and social participants. The university period is not only a stage of academic development but also a critical period for shaping long-term values, lifestyles, and behavioral patterns. Therefore, promoting carbon reduction behavior among university students may contribute to long-term environmental sustainability beyond the campus environment (Steg & Vlek, 2009).

In Thailand, environmental sustainability has received increasing attention due to the challenges associated with economic development, urbanization, and increasing energy consumption. Thai universities have gradually implemented sustainability-related initiatives, including green campus projects, environmental education programs, waste reduction campaigns, and student environmental activities. These initiatives aim to encourage students to participate in environmentally responsible practices and integrate sustainability principles into campus life.

However, existing studies suggest that environmental awareness does not always translate directly into consistent environmental behavior among Thai individuals. Vantamay (2018) found that although individuals may demonstrate environmental concern, the implementation of environmentally responsible behaviors can still be affected by various psychological and contextual factors. This indicates that understanding carbon reduction behavior requires examining not only environmental awareness but also the mechanisms that influence behavioral transformation.

Prior investigations in Thailand have primarily centered on green consumption, ecological attitudes, and sustainable buying actions. For instance, Maichum et al. (2016) showed that mental elements derived from the Theory of Planned Behavior might efficiently clarify green buying motivation among Thai shoppers. Such results suggest that personal perception performs a significant function in ecological conduct inside the Thai setting.

Consequently, carbon mitigation actions by college undergraduates encompass wider daily routines, involving power consumption, commuting, buying habits, and campus engagement. While comparisons with investigations into eco-friendly acquisitions exist, academic work analyzing the holistic development process of student carbon reduction conduct stays rather scarce. Specifically, the impact of societal and collective-

oriented psychological dynamics in molding learners' low-carbon activities demands additional exploration.

Consequently, this research concentrates on collegiate learners based in Thailand, encompassing both local Thai pupils and overseas scholars attending Thai tertiary educational facilities. Through analyzing carbon mitigation actions within the Thai academic environment, this inquiry seeks to offer a more profound insight into how personal awareness and societal psychological factors collectively influence low-carbon practical activities.

2.2 Theoretical Foundation

2.2.1 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB), introduced by Ajzen (1991), represents a highly significant conceptual structure for clarifying and forecasting personal actions. TPB builds upon the Theory of Reasoned Action by integrating perceived behavioral control, asserting that human conduct is not merely shaped by private motives but also affected by personal capacities and surrounding circumstances linked to executing the task.

Based on TPB, behavioral intention represents the direct precursor to actual conduct, whereas intention is mainly influenced by three psychological dimensions: attitude, subjective norm, and perceived behavioral control (Ajzen, 1991). Attitude denotes a person's comprehensive assessment of whether engaging in a specific action will yield favorable or unfavorable results. When people perceive that an action produces beneficial outcomes, they are more inclined to form positive evaluations and more robust behavioral intentions.

Subjective norm denotes the perceived societal pressure or endorsement from influential individuals concerning whether a person ought to engage in a specific action. Such vital parties might encompass relatives, companions, peers, organizations, or larger societal communities. People are more inclined to exhibit a behavior when they believe that those close to them endorse or anticipate such conduct (Ajzen, 1991).

Perceived behavioral control denotes a person's impression of their capacity, assets, prospects, and limitations concerning executing a specific action. Whenever people feel they have adequate proficiency and advantageous circumstances, they are more inclined

to carry out that behavior effectively. Consequently, perceived behavioral control embodies not merely personal self-assurance but also the perceived practicality of implementing that particular activity (Ajzen, 1991).

TPB has gained extensive application within environmental behavioral studies since numerous pro-environmental actions necessitate people to evaluate individual advantages, societal norms, and operational limitations concurrently. Bamberg and Möser (2007), via a meta-analysis of pro-environmental conduct research, showed that psychological variables such as attitudes, norms, and perceived behavioral control substantially affect ecological activities. Likewise, Steg and Vlek (2009) maintained that environmental practices are molded by intricate interactions between personal drives and situational variables.

Regarding carbon mitigation actions, TPB offers a suitable structure for elucidating why college students opt to participate in low-carbon activities. Learners who view carbon reduction actions as beneficial are more inclined to foster favorable attitudes toward these activities. Those who feel backed by fellow students, institutions, and societal settings are more prone to undergo normative pressure. Additionally, individuals who assume they possess adequate expertise, assets, and chances are more likely to convert ecological desires into real conduct.

While TPB offers a robust framework for understanding personal-level action choices, its capacity to clarify how societal impact gets integrated into personal self-perception remains constrained. The subjective norm component within TPB primarily addresses observed external pressures, yet it fails to sufficiently illuminate the intricate psychological dynamics via which people align with collective ideals and proactively ensure behavioral coherence. Consequently, this research incorporates Social Identity Theory alongside collective identity to more profoundly elucidate the group-centric processes driving carbon mitigation activities.

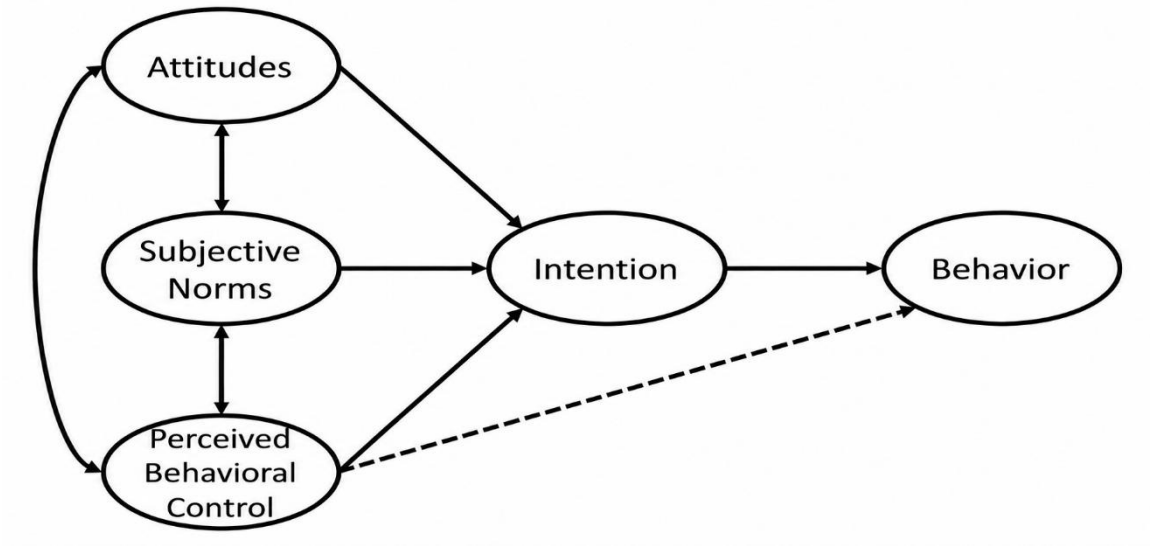

Figure 2. 1 Theory of Planned Behavior (Ajzen, 1991).

2.2.2 Social Identity Theory and Collective Identity

Social Identity Theory (SIT), formulated by Tajfel and Turner (1979), offers a crucial framework for interpreting how group affiliations shape personal opinions and actions. Diverging from models that concentrate solely on solitary choices, SIT highlights that people identify themselves not merely via private traits but additionally through their involvement within societal categories.

According to SIT, individuals develop social identities through three major processes: social categorization, social identification, and social comparison (Tajfel & Turner, 1979). Through social categorization, individuals classify themselves and others into different social groups. Through social identification, individuals incorporate group membership into their self-concept and develop emotional attachment to the group. Through social comparison, individuals evaluate their own group in relation to other groups and seek consistency between their identity and group values.

Collective identity is an important concept derived from the social identity perspective. It refers to the extent to which individuals perceive themselves as part of a group and internalize shared group values, goals, and responsibilities as part of their own identity (Tajfel & Turner, 1979). When individuals strongly identify with a group, they are more likely to adopt behaviors consistent with group expectations because maintaining behavioral consistency reinforces their sense of belonging.

In environmental behavior research, collective identity has increasingly been recognized as an important mechanism explaining sustainable actions. Fielding and Hornsey (2016) argued that environmental behaviors are influenced not only by individual attitudes but also by the social identities individuals hold. When environmental protection becomes an important component of group identity, individuals are more likely to view environmentally responsible behaviors as “what people like us do” rather than simply external recommendations.

Fritsche et al. (2018) further proposed the Social Identity Model of Pro-Environmental Action (SIMPEA), which explains how social identity processes influence environmental behavior. The model suggests that group identification, collective norms, and collective efficacy can encourage individuals to engage in pro-environmental actions because such behaviors become connected with group values and collective goals.

For university students, collective identity may play an important role in shaping carbon reduction behavior. Universities provide intensive social interaction environments where students participate in classes, organizations, dormitory life, and campus activities. When low-carbon practices become associated with campus identity or student group values, students may perceive such behaviors as part of their collective responsibility and maintain them more consistently.

Therefore, Social Identity Theory complements TPB by explaining the transformation from individual behavioral evaluation to group-based behavioral internalization. While TPB explains why individuals develop behavioral tendencies, SIT explains why these tendencies may become stable and sustained through identity-based processes.

2.2.3 Theoretical Integration: Distinction between Subjective Norm and Collective Identity

Although subjective norm and collective identity both involve social influence, they represent fundamentally different psychological mechanisms. Clarifying their distinction is essential for establishing the theoretical validity of this study model.

Based on TPB, subjective norm denotes a person's impression of societal anticipations from significant individuals concerning whether a specific action ought to be carried out (Ajzen, 1991). It represents external prescriptive force and centers on the inquiry:

"What do others expect me to do?"

For example, university students may engage in carbon reduction behavior because they believe their classmates, teachers, or universities expect them to save electricity, reduce waste, or participate in environmental activities. In this case, behavior is influenced by perceived approval, social expectations, and the desire to comply with external norms.

In contrast, collective identity refers to the internal psychological process through which individuals define themselves as members of a group and incorporate group values into their self-concept (Tajfel & Turner, 1979). It focuses on the question:

"Who are we, and what values represent our group?"

When students develop strong collective identity related to environmental protection, carbon reduction behavior is no longer performed merely because others expect it. Instead, students perceive low-carbon practices as consistent with their group identity and personal values. Therefore, behavior becomes internally motivated and identity-consistent.

Table 2. 1 Comparison of the concepts of two variables

Concept	**Subjective Norm**	**Collective Identity**
Theoretical origin	Theory of Planned Behavior	Social Identity Theory
Core mechanism	External social expectation	Internal identity identification
Main question	What should I do because others expect it?	What should we do because this represents who we are?
Behavioral process	Norm compliance	Identity consistency
Psychological level	External influence	Internalization

This differentiation clarifies why shared identity functions as a mediating link between TPB factors and carbon mitigation actions. Attitudinal stance, social pressure, and perceived capability account for the development of personal behavioral inclinations. Nevertheless, such inclinations might become more robust and enduring as people incorporate green values into their collective group consciousness.

Consequently, this research combines TPB with Social Identity Theory by situating collective identity as a mental link between personal perception and real carbon mitigation actions. Such conceptual merging offers a more holistic interpretation of how carbon reduction practices evolve from personal assessment, social impact, and identity assimilation.

2.3 Empirical Review of Carbon Reduction Behavior

2.3.1 Empirical Studies on Individual Psychological Factors and Carbon Reduction Behavior

Prior empirical investigations regarding environmental conduct have thoroughly explored how personal psychological variables affect carbon mitigation and other pro-nature activities. Within diverse conceptual viewpoints, the Theory of Planned Behavior (TPB) introduced by Ajzen (1991) has emerged as one of the most frequently utilized models for clarifying environmentally accountable behaviors.

A significant amount of scholarship has shown that personal cognitive elements, such as behavioral attitudes, subjective norms, and perceived behavioral control, exert crucial influences on molding ecological conduct. Bamberg and Möser (2007) performed a meta-analysis regarding pro-environmental conduct research and discovered that psychological factors, specifically attitudes, perceived norms, and perceived behavioral control, notably assisted in clarifying environmentally accountable behaviors. Their results imply that ecological activity is not dictated solely by ecological literacy but also by people's appraisals, social perceptions, and perceived capacity to execute particular actions.

Similarly, Steg and Vlek (2009) emphasized that pro-environmental behaviors involve complex decision-making processes in which individuals consider environmental benefits, personal convenience, social expectations, and behavioral feasibility. Therefore, individual cognition represents an important foundation for understanding why people choose to engage in carbon reduction practices.

Empirical research has also supported the applicability of TPB in different environmental behavior contexts. For example, TPB-based studies have successfully explained behaviors including energy conservation, green consumption, recycling, and

sustainable transportation choices. Within the Thai context, Maichum et al. (2016) demonstrated that TPB-related psychological factors significantly influenced green purchase intention among Thai consumers. Vantamay (2018) further indicated that environmental knowledge, attitudes, and behavioral factors contributed to sustainable consumption behavior among Thai individuals.

Although these studies provide strong evidence for the importance of individual psychological mechanisms, most existing research has primarily focused on how personal cognition leads to behavioral intention or action. Less attention has been given to how these individual-level factors are transformed into stable behavioral patterns through social relationships, group membership, and identity-based processes.

2.3.2 Empirical Studies on Collective Identity and Environmental Behavior

In addition to individual psychological factors, recent environmental behavior research has increasingly emphasized the influence of social identity and group-related mechanisms. Environmental behaviors are often embedded within social contexts, where individuals interact with communities, institutions, and social groups. Therefore, understanding how group identification influences individual behavior provides an important extension beyond traditional individual-level explanations.

Fielding and Hornsey (2016) reviewed climate change and environmental behavior research from a social identity perspective and argued that individuals' environmental actions are strongly influenced by their identification with relevant social groups. When environmental protection becomes associated with group identity, individuals are more likely to perceive environmental behaviors as consistent with group values rather than merely personal choices.

Fritsche et al. (2018) expanded the Social Identity Model of Pro-Environmental Action (SIMPEA), suggesting that social identity mechanisms shape ecological conduct via group standards, collective efficacy, and common environmental beliefs. This framework indicates that people who intensely affiliate with eco-conscious collectives are more inclined to perform pro-nature activities since these actions serve as displays of group belonging and shared communal accountability.

Empirical evidence has also shown that identity-related factors contribute to behavioral consistency. Van der Werff et al. (2013) found that environmental self-identity significantly predicted environmental preferences, intentions, and behaviors, indicating

that identity provides an important psychological connection between environmental values and actual behavior.

However, existing studies on collective identity and environmental behavior have mainly examined identity as a direct predictor of environmental actions. Although these studies demonstrate that group identity influences behavior, limited research has explored how collective identity functions as a psychological mechanism connecting individual cognition and behavioral outcomes. In particular, the mediating role of collective identity between TPB factors and carbon reduction behavior remains insufficiently examined.

2.3.3 Empirical Studies on Carbon Reduction Behavior in Thai Higher Education Context

Thailand provides an important research context for examining carbon reduction behavior because universities have increasingly emphasized environmental sustainability and green campus development. Thai higher education institutions have introduced various sustainability initiatives, including environmental education programs, waste reduction campaigns, energy-saving projects, and student environmental activities.

Existing empirical studies in Thailand have mainly focused on green consumption, environmental awareness, and sustainable purchasing behavior. Maichum et al. (2016) examined green purchasing intention among Thai consumers and found that TPB variables provided significant explanatory power in understanding environmentally responsible consumption decisions. This study demonstrated the applicability of TPB within the Thai cultural context.

Likewise, Vantamay (2018) examined sustainable consumption patterns within Thai citizens and underscored the significance of mental and conductive elements in encouraging ecological-conscious actions. Such research offers crucial data concerning ecological habit development in Thailand.

However, compared with studies in Western countries, empirical research specifically examining carbon reduction behavior among university students in Thailand remains limited. Existing Thai studies have mainly focused on consumption-related environmental behaviors, while comprehensive low-carbon practices involving energy conservation, transportation choices, and daily sustainability behaviors have received less attention.

Furthermore, Thai universities represent complex social environments where students are influenced by peers, campus culture, and student communities. Despite the importance of social interaction in university settings, the role of collective identity in shaping students' carbon reduction behavior has not been sufficiently investigated.

2.3.4 Literature Review and Research Gap

Based on the previous empirical studies, several important research gaps can be identified.

Currently, previous research has offered significant proof concerning the impact of personal mental variables on carbon mitigation and eco-friendly conduct. Investigations grounded in TPB have shown that behavioral attitude, subjective norm, and perceived behavioral control are vital predictors of ecological activities. However, current research has mainly emphasized individual cognitive mechanisms and has not sufficiently explained how these factors develop into stable and internally motivated behaviors. In particular, the process through which individuals transform external social influences into internal behavioral commitment remains unclear.

Second, although TPB has been widely applied in environmental behavior research, the theory primarily explains behavior formation from an individual decision-making perspective. Subjective norm within TPB reflects individuals' perceptions of external expectations from important others, but it does not fully explain deeper psychological processes such as group identification, value internalization, and identity consistency. Therefore, integrating TPB with Social Identity Theory may provide additional explanatory power by explaining how individual cognition and social influence are transformed into sustained behavioral actions.

Third, although previous studies have increasingly recognized the importance of social identity and collective mechanisms in environmental behavior, limited empirical research has examined collective identity as a mediating mechanism between individual psychological factors and carbon reduction behavior. Existing studies have mainly focused on the direct influence of social identity on environmental actions, leaving insufficient understanding of how collective identity functions as a bridge from cognition to behavior.

Fourth, empirical research on carbon reduction behavior among university students in Thailand remains relatively insufficient. Previous Thai studies have mainly examined green consumption and environmental awareness, while limited attention has been given to the comprehensive formation mechanism of carbon reduction behavior within higher education contexts. Moreover, the role of collective identity in influencing students' low-carbon practices has not been adequately explored.

Consequently, this research fills such academic voids by merging the Theory of Planned Behavior with Social Identity Theory. Precisely, this inquiry incorporates collective identity as a mediating factor linking behavioral attitudes, subjective norms, perceived behavioral control, and carbon reduction actions. Via this combined conceptual structure, this study seeks to clarify not merely how university pupils cultivate low-carbon conduct inclinations but also how these inclinations are internalized and converted into real carbon reduction practices within the Thai tertiary education environment.

2.4 Research Model

Grounded in the conceptual bases and practical insights presented within earlier portions, this investigation develops a comprehensive analytical framework to clarify the development process of carbon mitigation actions among college students residing in Thailand. This suggested structure merges the Theory of Planned Behavior (TPB) with Social Identity Theory to explore how personal cognitive elements and shared group identity collectively shape carbon reduction practices.

The conceptual framework for this model rests upon the premise that carbon mitigation actions are influenced by multiple psychological variables rather than a single one. Rather than being static, such conduct evolves via a sequence including personal assessment, societal impact, identity assimilation, and practical execution. Consequently, this research integrates both personal and collective elements to offer a more thorough clarification of carbon reduction activities.

According to TPB theory, behavioral attitude, subjective norm, and perceived behavioral control serve as three crucial antecedents for personal behavioral choices (Ajzen, 1991). Behavioral attitude indicates students' appraisals of carbon reduction practices, encompassing their belief that low-carbon activities are regarded as meaningful

and advantageous. Subjective norm denotes the perceived anticipations and backing from significant social circles, including classmates, educational institutions, and relatives. Perceived behavioral control refers to students' perceptions concerning whether they possess adequate assets, skills, and prospects to execute carbon reduction actions.

Utilizing TPB, this research suggests that behavioral attitude, subjective norm, and perceived behavioral control directly affect carbon reduction actions. Learners who possess favorable appraisals of low-carbon activities, perceive greater social endorsement, and feel more competent in executing such actions are anticipated to exhibit higher degrees of carbon reduction conduct.

However, TPB mainly explains behavioral formation from an individual cognitive perspective and provides limited explanation regarding how social influence becomes internalized as part of individuals' identity. To address this limitation, this study introduces collective identity based on Social Identity Theory as a mediating variable.

Collective identity represents the extent to which individuals perceive low-carbon behavior as a shared value and responsibility of the groups to which they belong. When students identify strongly with a group that values environmental protection, low-carbon behavior may become more than an individual choice; instead, it becomes an identity-consistent action reflecting group membership and shared values (Tajfel & Turner, 1979; Fielding & Hornsey, 2016).

Consequently, shared identity is regarded as a mental link connecting TPB elements with carbon mitigation actions. Precisely, conductive attitudes, social norms, and perceived control over behavior might not merely impact carbon-cutting actions but could also reinforce students' communal affiliation with low-carbon principles. Once these values are integrated into collective identity, pupils are more inclined to sustain stable carbon-cutting practices.

This conceptual framework encompasses dual tiers of behavioral impact. The initial tier investigates the immediate influences of TPB elements and group identity on carbon mitigation actions. The subsequent tier explores the mediating function of collective identity, clarifying how private perceptions and societal pressure are translated into tangible practical conduct via the process of identity integration.

Consequently, the theoretical structure of this research suggests that behavioral attitude, subjective norm, and perceived behavioral control affect carbon reduction actions both directly and indirectly via collective identity. This unified framework expands conventional TPB by integrating a social identity viewpoint and offers a more holistic interpretation of carbon reduction conduct among university students in Thailand.

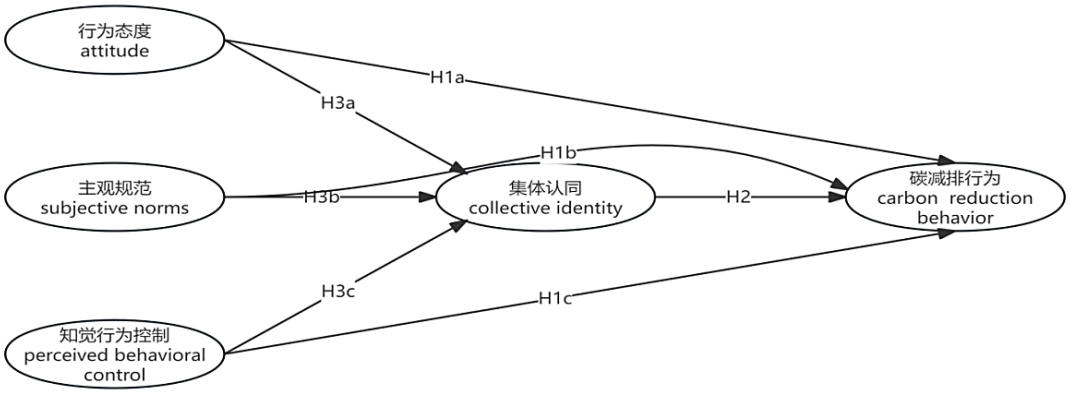

Figure 2. 2 Hypothetical Model Diagram

2.5 Research Hypotheses

Building upon the theoretical synthesis of the Theory of Planned Behavior (TPB) and Social Identity Theory, this research suggests that carbon reduction practices among Thai university students are shaped by both personal psychological elements and communal identity processes. Precisely, behavioral attitude, subjective norm, and perceived behavioral control constitute individual-level cognitive variables, whereas collective identity serves as a group-level psychological framework that promotes the transition from personal awareness into real action.

The subsequent conjectures are formulated according to the correlations suggested within the conceptual framework.

2.5.1 Behavioral Attitude and Carbon Reduction Behavior

Based on the Theory of Planned Behavior, behavioral attitude signifies a person's total assessment regarding engaging in a particular action. Those who view a behavior as advantageous and significant are more inclined to foster favorable behavioral inclinations and execute that activity (Ajzen, 1991).

Regarding carbon mitigation activities, learners who perceive that low-emission initiatives could aid ecological preservation, communal accountability, and enduring progress are more inclined to engage in power saving, eco-friendly mobility, and eco-conscious purchasing habits. Former quantitative investigations have repeatedly shown that favorable ecological perspectives are crucial indicators of eco-friendly conduct (Bamberg & Möser, 2007; Steg & Vlek, 2009).

Therefore, this study proposes:

H1a: Procedural attitude exerts a substantial affirmative influence upon carbon mitigation actions.

2.5.2 Subjective Norm and Carbon Reduction Behavior

Subjective norm refers to individuals' perceptions of social expectations from important others regarding whether they should perform a particular behavior (Ajzen, 1991). In environmental behavior contexts, individuals are often influenced by expectations from family members, peers, institutions, and social groups.

For university students, campus environments provide important sources of normative influence. When students perceive that peers, teachers, and universities support carbon reduction practices, they may feel greater social motivation to engage in such behaviors. Previous research has confirmed that perceived social norms significantly influence pro-environmental actions because individuals tend to adjust their behaviors according to socially expected standards (Bamberg & Möser, 2007; Cialdini et al., 1990).

Therefore, this study proposes:

H1b: Subjective norm has a significant positive effect on carbon reduction behavior.

2.5.3 Perceived Behavioral Control and Carbon Reduction Behavior

Perceived behavioral control signifies people's views concerning their capacity, assets, and chances to execute a specific action (Ajzen, 1991). When persons feel that a task is realistic and under their management, they tend to convert behavioral intentions into genuine activities.

Reducing carbon emissions frequently demands tangible prerequisites, including proximity to recycling centers, the presence of eco-friendly transport options, and familiarity with ecological conservation methods. Consequently, pupils who feel a greater degree of agency regarding executing low-carbon actions are anticipated to exhibit

elevated degrees of carbon mitigation conduct. Prior research has indicated that perceived behavioral control serves as a crucial determinant of pro-environmental activities since it diminishes perceived obstacles to implementation (Bamberg & Möser, 2007; Steg & Vlek, 2009).

Therefore, this study proposes:

H1c: Perceived self-efficacy exerts a substantial favorable influence upon carbon mitigation actions.

2.5.4 Collective Identity and Carbon Reduction Behavior

Social Identity Theory posits that people's actions are shaped by their affiliation with societal groups and their need to preserve coherence with collective norms (Tajfel & Turner, 1979). When persons view specific principles or conduct as vital elements of their collective identity, they are more inclined to engage in behaviors aligned with that identity.

Within ecological behavior studies, communal identity has been proven to motivate sustainable practices by shifting environmental conservation from a personal inclination into a collective collective duty. Fielding and Hornsey (2016) contended that persons are more inclined to participate in green activities when these tasks are linked with significant social affiliations. Likewise, Fritsche et al. (2018) illustrated that collective belonging and social values could foster pro-nature conduct via identity-oriented processes.

Regarding college pupils, once carbon mitigation is linked with institutional prestige or peer-group principles, learners might view sustainable habits as manifestations of "our identity" instead of just discretionary personal activities.

Therefore, this study proposes:

H2: Group identity exerts a substantial beneficial influence on carbon mitigation actions.

2.5.5 Mediating Role of Collective Identity

Although TPB explains how individual cognitive factors influence behavior, individual cognition alone may not fully explain how environmental intentions become stable behavioral practices. Social Identity Theory suggests that social influence can become internalized when individuals identify strongly with a group and incorporate group values into their self-concept (Tajfel & Turner, 1979).

In this study, collective identity is proposed as a mediating mechanism between TPB factors and carbon reduction behavior. Behavioral attitude may strengthen students' acceptance of low-carbon values, subjective norm may enhance perceptions that low-carbon practices represent shared group expectations, and perceived behavioral control may increase confidence in participating in group-based environmental actions. Through these processes, individual cognition may be transformed into stronger collective identification, which subsequently promotes actual carbon reduction behavior.

Previous research indicates that identity-related factors serve as important mechanisms connecting environmental values and behaviors. Fielding and Hornsey (2016) and Fritsche et al. (2018) emphasized that social identity processes can transform environmental concerns into collective action. Therefore, collective identity may explain how individual psychological factors are translated into sustained carbon reduction behavior.

Accordingly, this study proposes the following mediation hypotheses:

H3a: Collective identity mediates the relationship between behavioral attitude and carbon reduction behavior.

H3b: Collective identity mediates the relationship between subjective norm and carbon reduction behavior.

H3c: Collective identity mediates the relationship between perceived behavioral control and carbon reduction behavior.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Research Design

3.1.1 Research Type

This research utilizes a quantitative investigative approach, gathering information via surveys to examine how group identity impacts the carbon mitigation actions of Thai university students via elements like behavioral intentions, subjective norms, and perceived control over behavior according to the Theory of Planned Behavior (TPB). Quantitative methodologies are extremely flexible and reliable, efficiently evaluating and examining correlations among various factors and uncovering causal dynamics. Within this work, numerical data will be examined utilizing structural equation modeling (SEM) to evaluate the presumed connections between diverse variables.

This research utilized a cross-sectional approach, which entails gathering and examining information at a particular moment in time. Cross-sectional frameworks efficiently depict students' conduct perspectives, mental states, and action inclinations throughout a specific timeframe, and compared to longitudinal investigations, they minimize investigation duration and expenses. Via this cross-sectional method, this research could, to a degree, uncover the primary psychological elements among Thai university pupils making decisions regarding carbon mitigation.

3.1.2 Research Model Construction

The conceptual structure of this research integrates the Theory of Planned Behavior (TPB) with Social Identity Theory (SIT). Per TPB, personal conduct is shaped by three primary elements: behavioral attitudes, subjective norms, and perceived behavioral control. Group identity, a fundamental notion within SIT, impacts individual actions via collective standards and a feeling of communal affiliation. More precisely, people advance the execution of low-carbon practices by associating with eco-friendly conduct as a component of their collective identity.

Consequently, the primary framework of this research employs collective identity as a mediating factor to investigate its impact on personal carbon mitigation actions under the TPB structure. This conceptual model considers behavioral attitudes, subjective norms, and perceived behavioral control as predictors, carbon reduction actions as the outcome variable, and collective identity as the mediator, constructing the structural linkage among behavioral attitudes, social norms, and perceived control regarding low-carbon practices.

3.1.3 Research Process

The investigative framework for this project is structured into the following primary phases:

The systematic literature survey, via broad literature examination, seeks to grasp the investigative outcomes regarding carbon emission mitigation actions, planning behavior frameworks, and social identity concepts both at home and abroad, and to define the conceptual structure and research propositions of this project.

The questionnaire was designed and a pre-survey

The research was carried out. A systematic questionnaire was formulated, encompassing factors like behavioral intentions, subjective norms, perceived behavioral control, group identity, and carbon reduction actions. A preliminary survey was performed to confirm the dependability and validity of the instrument, and adjustments were performed according to the responses.

Data collection was conducted

Online surveys were disseminated across Thai university premises via digital platforms to gather a reliable dataset. The total research population was planned at 350, while around 300 effective responses were finally obtained to guarantee the analytical strength of this investigation.

Data analysis

The research utilized descriptive statistical techniques, reliability and validity assessments, alongside structural equation modeling (SEM) to evaluate the gathered information, validate conceptual associations, and examine the moderating function of collective identity regarding low-carbon actions.

The results interpretation and discussion section

This study elucidates the analytical outcomes, exploring how shared identities impact Thai university students' carbon mitigation actions via behavioral beliefs, social pressures, and perceived capability factors within the TPB framework. Constructive policy suggestions and actionable insights are derived from these empirical discoveries.

Research Summary and Future Prospects

This article synthesizes the primary results of this investigation, examines its constraints, and suggests paths for subsequent studies.

3.2 Population, Sampling Method, and Sample Selection

3.2.1 Target Audience

The focus group for this investigation consists of college learners residing within Thailand. The motivations for selecting campus students as the primary research participants include the following:

University students possess a strong environmental awareness and behavioral shaping ability: As the global climate change problem becomes increasingly serious, the environmental awareness and behavior of university students are gradually gaining attention, with many students showing a high level of concern for environmental protection, energy conservation, and emission reduction. Furthermore, as the backbone of future society, university students' carbon reduction behaviors have a demonstrative effect and are of great significance in promoting the popularization of environmentally friendly behaviors in society.

Low-carbon behavior among university students is significantly influenced by collective identity: within a collectivist cultural context, university students' behavior is often strongly influenced by group norms and collective identity. Therefore, their response to and implementation of low-carbon behaviors may be more driven by group identity. Studying this group's low-carbon behavior can provide valuable insights for broader interventions in group behavior.

College pupils occupy a crucial phase of societal conduct evolution: they are engaged in the gradual formation of their ethical principles and conduct standards. Consequently, their eco-friendly actions are remarkably flexible and readily shaped by social psychological elements like collective identity and social conventions, rendering them an ideal research subject for this inquiry.

3.2.2 Sample Size and Sample Selection Methods

To guarantee the practicality of information gathering and the appropriateness of the participants for the investigation goals, this research shall utilize convenience sampling to acquire data from college students within Bangkok, Thailand. Convenience sampling is a commonly used non-probability sampling method in social science research, especially when the target population is clearly defined but a complete sampling frame is difficult to obtain (Etikan, Musa, & Alkassim, 2016). Since this study focuses on university students studying in Thailand' carbon reduction behavior, selecting respondents from universities in Bangkok is practical and appropriate. Bangkok is one of Thailand's major higher education centers, where universities are relatively concentrated and students from different academic backgrounds can be reached more efficiently. Therefore, the study will distribute questionnaires to students from several Bangkok-based universities through online and offline channels, such as university student groups, class communication groups, student organizations, social media platforms, and campus-related networks.

Although convenience sampling may limit the generalizability of the findings because participants are not selected randomly, this study will take several measures to reduce sample homogeneity bias. First, the questionnaire will be distributed across multiple universities in Bangkok rather than relying on a single institution. Second, respondents from different academic years, education levels, and major categories will be included as far as possible. Third, the study will use screening questions to ensure that participants meet the inclusion criteria, such as being currently enrolled university students, aged between 18 and 30, and having basic awareness of carbon reduction behavior. Fourth, demographic variables, including gender, age, academic year, major type, university type, environmental course experience, and participation in environmental clubs or volunteer activities, will be collected for descriptive analysis and possible control-variable analysis. These procedures can help improve sample diversity and reduce the risk that the results are driven by a single subgroup.

The age range for participants is set at 18 and above. This range is consistent with the general age distribution of undergraduate and postgraduate students in higher education. In Thailand, students normally enter higher education after completing secondary education, and undergraduate and graduate study are generally concentrated in young adulthood. In addition, the National Statistical Office of Thailand reports student statistics by school-age population and education level, indicating that formal education participation is strongly associated with age-group structure (National Statistical Office of Thailand, 2025). Therefore, setting the age range at 18–30 can include most traditional undergraduate and postgraduate students while excluding respondents whose age and student status may not fit the main research population. This age range also helps maintain sample consistency and improves the interpretability of the findings.

3.2.3 Inclusion and Exclusion Criteria for Sample Selection

This research intends to gather no fewer than 300 reliable survey responses. The essential sample volume was calculated according to the multivariate path analysis technique and the structural equation modeling (SEM) framework applied within this investigation. As this project seeks to investigate the direct impacts of behavioral attitude, subjective norm, perceived behavioral control, and collective identity on carbon mitigation actions, along with the mediating function of collective identity, a sufficient sample size is essential to guarantee robust parameter estimation and adequate statistical power.

Initially, this research utilizes Green's (1991) established sample-size determination equation for multiple regression:

$$N \geq 50 + 8m$$

Within this equation, m denotes the count of autonomous predictor factors. For the current research, the fundamental explanatory variables concerning carbon mitigation actions encompass behavioral attitude, subjective norm, perceived behavioral control, and collective identity. Consequently, m = 4. The smallest dataset required by Green's methodology is determined as follows:

$$N \geq 50 + 8 \times 4 = 82$$

This finding suggests that a minimum of 82 participants are necessary for fundamental multiple regression evaluation. Nevertheless, this baseline figure is inadequate for the comprehensive analytical techniques utilized in this research, since this investigation will additionally perform confirmatory factor analysis (CFA), structural

equation modeling (SEM), and Bootstrap mediation assessment. SEM concurrently estimates the measurement model alongside the structural model, and consequently typically demands a larger sample size than traditional regression analysis.

Furthermore, the sample quantity was subsequently determined based on the count of observed indicators within the refined survey. The adjusted questionnaire encompasses five latent constructs: Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction behavior. Every latent construct comprises six measurement factors. Consequently, the overall quantity of fundamental observed indicators is computed as follows:

Number of observed variables = 5 latent variables × 6 items = 30 items

Drawing from conventional practices in multivariate statistics and SEM where a sample size must be no less than tenfold the number of observed indicators, the minimum necessary sample volume for this research is determined as below:

Minimum sample size = Number of observed variables × 10

Minimum sample size = 30 × 10 = 300

In contrast to the basic threshold derived from Green's regression equation, the SEM-derived estimation is more suitable for this investigation as the conceptual framework incorporates several latent factors, various manifest variables, both direct and indirect connections. Hair, Black, Babin, and Anderson (2014) proposed that a larger dataset enhances the robustness of parameter determination within multivariate frameworks. Cohen (1992) similarly highlighted that sample-size design is crucial for augmenting statistical potency and the dependability of empirical findings. Furthermore, Memon et al. (2020) observed that SEM sample-size determination must account for model intricacy, the quantity of indicators, estimation techniques, and power levels. Consequently, this research establishes the intended sample quantity at no less than 300 authentic survey responses.

To address potential invalid responses and data gaps, around 350 questionnaires shall be dispatched. The anticipated valid response proportion is determined as follows:

Expected valid response rate = 300 / 350 × 100% = 85.7%

Consequently, allocating roughly 350 surveys is anticipated to yield about 300 reliable returns following the rejection of flawed forms. Such a setup facilitates guaranteeing that the ultimate participant pool satisfies the basic criteria for CFA, SEM, plus Bootstrap mediation testing.

Following the data gathering phase, every questionnaire shall be filtered based on distinct inclusion and exclusion standards. The defined inclusion criteria are as follows: (1) the participant must be a current university student within Thailand; (2) the participant must be aged between 18 and 30; (3) the participant must engage in voluntary participation and finish the survey according to informed consent; and (4) the participant must finalize the essential scale components concerning Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction actions.

An inquiry form shall be deemed invalid and discarded provided that it satisfies any of the subsequent requirements: (1) the participant is not presently studying at a Thai college; (2) participants were under 18 years of age; (3) over 10% of the primary scale questions remain unanswered; (4) every or almost every Likert-scale question is marked with a single choice, reflecting straight-lining; (5) the completion duration is excessively brief, implying that the subject might not have reviewed the questions thoroughly; or (6) the replies demonstrate evident logical inconsistencies, like choosing “completely unfamiliar with carbon mitigation actions” while offering extremely detailed responses to associated knowledge or practice inquiries. Such standards are utilized to guarantee data integrity and minimize operational biases prior to performing descriptive statistics, reliability assessment, confirmatory factor analysis, and structural equation modeling.

3.2.4 Representativeness and Limitations of the Sample

Despite this research utilizing convenience sampling to identify participants across various institutions, this approach might be vulnerable to selection bias. For instance, learners from certain campuses might exhibit more robust ecological consciousness or greater engagement compared to peers from different institutions, thereby potentially impacting the overall applicability of the findings. Moreover, since this investigation mainly targets college undergraduates residing in Thailand, the geographic and cultural breadth of the dataset remains fairly constrained, which could hinder the broad dissemination of these conclusions.

Nevertheless, since Thai university students constitute a prime exemplar of collectivist society, investigations into their sustainable actions possess significant importance for grasping the influence of group identity on eco-friendly conduct. Consequently, even with specific constraints, this inquiry may nevertheless offer valuable conceptual backing and practical evidence regarding the socio-psychological dynamics underlying low-carbon lifestyle choices.

3.2.5 Sample Descriptive Statistics

Following data gathering, this research shall perform descriptive statistical evaluation to characterize the fundamental traits of the participants. Such descriptive metrics will encompass common demographic factors like gender, age, grade level, educational attainment, major category, and university classification. These elements are utilized to outline the total makeup of the subjects and to determine if the group comprises students from varied scholastic and socio-demographic origins.

Beyond basic demographic data, this research shall incorporate multiple control factors intimately linked to carbon mitigation actions, including whether participants have enrolled in classes concerning carbon reduction or sustainable growth, whether they have engaged in ecological clubs or charitable efforts, their awareness of carbon-saving practices, and their primary channels for acquiring carbon-cutting data. Such variables are integrated since prior literature suggests that ecological schooling, environmental expertise, campus environments, and societal impacts might influence persons' Perceptions and actions (Steg & Vlek, 2009; Fielding & Hornsey, 2016). For collegiate students, encounters like enrolling in sustainability-oriented modules or joining environmental initiatives might enhance their consciousness of low-carbon conduct and reinforce their readiness to participate in such activities.

Concretely, the descriptive analysis shall present the count and proportion for nominal variables, including gender, academic standing, field of study, institution category, experience in environmental courses, and involvement in ecological clubs or charitable work. Regarding continuous metrics like age, the average, standard deviation, lowest figure, and highest figure will be documented. Furthermore, the spread of participants' knowledge regarding carbon-cutting actions and their data channels will be outlined. This assists the investigator in determining whether subjects possess adequate foundational understanding of the investigated subject.

Integrating these specific thematic variables also assists in minimizing the potential hazard of excluding underlying contextual elements during subsequent evaluations. For instance, learners who have undergone ecological instruction or engaged in green initiatives might exhibit more robust Attitudes, subjective norms, collective identity, and carbon reduction practices compared to those lacking similar backgrounds. Consequently, such factors could be utilized not merely for narrative descriptions, but also as regulatory variables or classification variables within following statistical modeling as needed. This approach enables the research to more precisely investigate the correlations between behavioral orientations, subjective norms, perceived behavioral control, collective identity, and carbon reduction actions.

Based upon the aforementioned descriptive statistical evaluation, this research is capable of illustrating the variety and fundamental typicality of the participants more distinctly. It also offers a more robust foundation for explaining the empirical outcomes. By incorporating both broad demographic factors and study-related regulatory variables, the investigation can more effectively clarify if variations in carbon mitigation actions are linked to individual backgrounds, academic training, campus involvement, or data availability.

3.3 Questionnaire Design

To guarantee the empirical precision, validity, and consistency of the assessment instruments, this research developed a systematic quantitative survey grounded in the Theory of Planned Behavior (TPB) and Social Identity Theory (SIT), considering the particular context of Thai university students. The TPB offers a conceptual framework for evaluating behavioral attitude, subjective norm, and perceived behavioral control, which are deemed vital psychological precursors of personal actions (Ajzen, 1991). Social Identity Theory establishes a theoretical structure for assessing collective identity, highlighting that people might identify themselves via group affiliation and behave in alignment with communal values and standards (Tajfel & Turner, 1979). In addition, the questionnaire items were adjusted and optimized through a systematic literature review, expert consultation, and pre-survey testing to improve content validity and contextual fit. Such procedures are consistent with the general principles of scale development, which

emphasize theoretical grounding, item refinement, and validity evaluation in the development of multi-item measures (DeVellis, 2016; Netemeyer, Bearden, & Sharma, 2003).

The questionnaire was designed to measure low-carbon behavior and its psychological antecedents among university students studying in Thailand, including both Thai domestic students and international students enrolled in Thai higher education institutions. This survey comprised six primary segments: demographic data, Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction behavior. Every latent construct was evaluated via a seven-point Likert scale, spanning from 1 = “strongly disagree” to 7 = “strongly agree.” The Likert scale is extensively utilized in attitude and behavioral studies since it enables participants to articulate various levels of agreement with a specific item (Likert, 1932). A seven-point scale was utilized within this research to offer greater response flexibility and to capture participants’ opinions and perceptions with greater accuracy.

3.3.1 Demographic Information

The initial segment of this survey gathered fundamental demographic details from participants, encompassing gender, age, educational background, field of study, current year, and the specific university category. In addition to these general demographic variables, this study also included topic-related control variables, such as whether respondents had participated in environmental or sustainability-related courses, whether they had joined environmental clubs or volunteer activities, their familiarity with carbon reduction behavior, and their main sources of low-carbon information. These variables were used to describe the sample characteristics and to control for the possible influence of background factors on carbon reduction behavior. By collecting this information, the study can better examine whether students’ carbon reduction behavior differs across demographic backgrounds, educational exposure, environmental participation, and information access.

3.3.2 Measurement of Attitude

Attitude denotes a person’s favorable or unfavorable perception of low-carbon actions. Based on the Theory of Planned Behavior, this attitude regarding actions is typically developed via an individual's assessment of the potential consequences of a particular conduct (Ajzen, 1991). In this study, Attitude measures whether university

students studying in Thailand believe that low-carbon behavior is beneficial, meaningful, responsible, and worth practicing. The measurement items were adapted from the theoretical framework of Ajzen (1991) and previous pro-environmental behavior studies by Bamberg and Möser (2007) and Steg and Vlek (2009).

The revised scale contains six items. These items measure students' evaluations of the environmental benefits, climate-change mitigation effects, sustainability value, responsibility meaning, and behavioral worth of low-carbon behavior. Example items include: "I believe that low-carbon behaviors have a significant positive impact on the environment," "I believe that energy conservation and emission reduction can help reduce global warming," and "I believe that low-carbon behaviors are worth practicing even if they may cause some inconvenience." Higher scores indicate a more positive attitude toward low-carbon behavior.

3.3.3 Measurement of Subjective Norms

Personal norms denote a person's perceived external pressures, endorsement, and assistance from significant others concerning whether they ought to engage in a specific activity (Ajzen, 1991). In this study, subjective norms measure whether university students studying in Thailand perceive that people around them, such as classmates, friends, teachers, university staff, and family members, expect, support, or encourage them to engage in low-carbon behavior. To avoid conceptual overlap with collective identity, the subjective norm items focus only on external social influence rather than group belonging, shared values, or identity internalization.

The revised subjective norm scale contains six items. These items measure perceived expectations and support from important others, peers, teachers, university staff, family members, and the surrounding social environment. Example items include: "People who are important to me think that I should engage in low-carbon behavior," "My classmates and friends encourage me to practice low-carbon behavior in daily life," and "My teachers or university staff support students in adopting low-carbon behavior." The items were mainly developed based on the Theory of Planned Behavior (Ajzen, 1991) and norm-related environmental behavior research (Cialdini, Reno, & Kallgren, 1990; Schultz et al., 2007). Higher scores indicate stronger perceived social support and normative pressure for low-carbon behavior.

3.3.4 Measurement of Perceived Behavioral Control

Perceived Behavioral Control signifies a person's assessment of their capacity, assets, prospects, and practicality to execute low-carbon actions. Within the Theory of Planned Behavior, perceived behavioral control indicates the degree to which persons feel they can effectively carry out a behavior under current circumstances (Ajzen, 1991). In this research, Perceived Behavioral Control evaluates Thai university students' perceived potential to participate in low-carbon mobility, energy conservation, eco-friendly purchasing, and resource-efficient habits.

The revised scale contains six items. These items measure students' perceived ability to choose low-carbon travel methods, save energy, select environmentally friendly products, reduce unnecessary resource consumption, and practice low-carbon behavior under current living conditions. Example items include: "I believe I have the ability to choose low-carbon travel methods in daily life," "I believe I can take energy-saving actions to reduce energy waste," and "I believe that practicing low-carbon behavior is feasible for me under my current living conditions." These items were developed based on Ajzen's (1991) TPB framework and previous pro-environmental behavior studies (Bamberg & Möser, 2007; Steg & Vlek, 2009). Higher scores indicate stronger perceived control over low-carbon behavior.

3.3.5 Measurement of Collective Identity

Group identity signifies the degree to which people view low-carbon actions as integral to their collective self-image, common values, communal obligations, and feeling of affiliation. Grounded in Social Identity Theory, people often establish their identities via group participation and are likely to behave in manners aligned with communal principles and standards (Tajfel & Turner, 1979). Within this research, collective identity examines whether Thai university students recognize low-carbon practices as belonging to the mutual identity and duty of the student community.

The revised collective identity scale contains six items. These items measure shared group values, identity consistency, group belonging, identification with low-carbon student groups, desired group membership, and connection with environmentally responsible students. Example items include: "I see low-carbon behavior as part of the shared values of university students," "Being low-carbon is consistent with my identity as a responsible university student," and "I feel a sense of belonging when I participate in

low-carbon activities with other students." Compared with the previous version, items that mainly reflected behavioral demonstration, such as "setting an example for the school and society," were removed because they did not directly measure collective identity. The revised items were adapted from Social Identity Theory and environmental identity research (Tajfel & Turner, 1979; Leach et al., 2008; Fielding & Hornsey, 2016; Fritsche et al., 2018). Higher scores indicate stronger collective identity related to low-carbon behavior.

3.3.6 Measurement of Carbon Reduction Behavior

Carbon reduction behavior is the dependent variable in this study. It refers to actual low-carbon actions taken by university students studying in Thailand in daily life, including energy saving, low-carbon travel, green consumption, reduction of single-use plastics, recycling, and resource-saving practices. Previous environmental behavior research emphasizes that pro-environmental behavior should refer to actual actions that may influence environmental outcomes rather than only behavioral intention (Stern, 2000; Steg & Vlek, 2009). Therefore, this study revised the original intention-based wording, such as "I plan to" or "I intend to," into actual behavior expressions based on respondents' behavior during the past month.

The revised carbon reduction behavior scale contains six items. These items measure actual low-carbon travel, reduction of single-use plastics, energy-saving behavior, green consumption, recycling or waste sorting, and general carbon-reduction practices. Example items include: "In the past month, I have reduced the use of private cars or ride-hailing services and chosen public transportation, walking, or cycling whenever possible," "In the past month, I have reduced my use of single-use plastic products," and "In the past month, I have turned off unnecessary lights, air conditioners, chargers, or other electrical appliances to save energy." Higher scores indicate a higher level of actual carbon reduction behavior.

Each latent variable within this research was assessed utilizing a seven-tier Likert format, spanning from 1 = "strongly disagree" to 7 = "strongly agree." Employing this seven-point Likert scale enables participants to articulate various levels of consensus more accurately and offers enhanced response diversity for following reliability evaluation, confirmatory factor analysis, and structural equation modeling.

3.3.7 Scale Fitting and Modification

To guarantee the practical utility and authenticity of the instrument, this research adjusted and refined the initial item pool. Every evaluation tool was derived from previously established ecological behavior surveys to maintain conceptual coherence and situational appropriateness (Hair et al., 2019; DeVellis, 2017). Through contrasting the primary scale with the revised versions, the substance validity and academic precision of the assessment were confirmed. This adaptation procedure involved streamlining the phrasing of inquiries, refining the vocabulary, and aligning with ethnic variations.

Table 3. 1 Measurement Sources and Adapted Items

Construct	Code	Measurement Focus	Revised Item in This Study	Main Source(s)	Adaptation Note
Attitude	ATT1	Environmental benefit evaluation	I believe that low-carbon behaviors have a significant positive impact on the environment.	Ajzen (1991); Steg & Vlek (2009)	Adapted to measure students' positive evaluation of the environmental consequences of low-carbon behavior.
Attitude	ATT2	Climate-change mitigation evaluation	I believe that energy conservation and emission reduction can help reduce global warming.	Bamberg & Möser (2007); Steg & Vlek (2009)	Adapted to connect low-carbon behavior with climate-change mitigation and emission reduction outcomes.
Attitude	ATT3	Sustainability value evaluation	I believe that practicing low-carbon behavior is meaningful for sustainable development.	Steg & Vlek (2009)	Adapted to reflect the perceived sustainability meaning of low-carbon behavior.
Attitude	ATT4	Responsibility-based attitude	I believe that adopting low-carbon behavior is a responsible choice for university students.	Ajzen (1991); Stern (2000)	Adapted to link behavioral attitude with university students' perceived environmental responsibility.
Attitude	ATT5	Cost–benefit evaluation	I believe that low-carbon behaviors are worth practicing even if they may cause some inconvenience.	Bamberg & Möser (2007); Steg & Vlek (2009)	Adapted to reflect students' positive attitude despite possible inconvenier or behavioral cost.

Table 3. 1 (Continued)

Construct	Code	Measurement Focus	Revised Item in This Study	Main Source(s)	Adaptation Note
Attitude	ATT6	Personal responsibility evaluation	I believe that everyone has a responsibility to reduce carbon emissions in daily life.	Stern (2000); Steg & Vlek (2009)	Adapted to measure the moral and responsibility-based evaluation of carbon reduction behavior.
Subjective Norms	SN1	Perceived expectation from important others	People who are important to me think that I should engage in low-carbon behavior.	Ajzen (1991)	Adapted from the TPB concept of perceived social expectation from important referents.
Subjective Norms	SN2	Peer encouragement	My classmates and friends encourage me to practice low-carbon behavior in daily life.	Ajzen (1991); Cialdini et al. (1990)	Adapted to the university context by specifying classmates and friends as social referents.
Subjective Norms	SN3	Institutional support	My teachers or university staff support students in adopting low-carbon behavior.	Ajzen (1991); Schultz et al. (2007)	Adapted to measure perceived support from educational authority figures and institutional actors.
Subjective Norms	SN4	Family support	My family supports me in saving energy, reducing waste, and choosing environmentally friendly options.	Ajzen (1991); Bamberg & Möser (2007)	Adapted to measure perceived family support for daily low-carbon behavior.
Subjective Norms	SN5	Social approval	People around me would approve if I practiced low-carbon behavior in daily life.	Ajzen (1991); Cialdini et al. (1990)	Adapted to measure perceived approval from the surrounding social environment.
Subjective Norms	SN6	Encouragement from surrounding people	I feel encouraged by people around me to make more environmentally friendly choices.	Ajzen (1991); Schultz et al. (2007)	Adapted to measure external encouragement while avoiding overlap with collective identity.
Perceived Behavioral Control	PBC1	Ability to choose low-carbon travel	I believe I have the ability to choose low-carbon travel methods in daily life.	Ajzen (1991); Steg & Vlek (2009)	Adapted to measure perceived ability to engage in low-carbon travel.

Table 3. 1 (Continued)

Construct	Code	Measurement Focus	Revised Item in This Study	Main Source(s)	Adaptation Note
Perceived Behavioral Control	PBC2	Ability to save energy	I believe I can take energy-saving actions to reduce energy waste.	Ajzen (1991); Bamberg & Möser (2007)	Adapted to measure perceived ability to perform energy-saving behavior.
Perceived Behavioral Control	PBC3	Knowledge of green consumption	I know how to choose green and environmentally friendly products.	Ajzen (1991); Steg & Vlek (2009)	Adapted to measure perceived knowledge and capability in green consumption.
Perceived Behavioral Control	PBC4	Ability to reduce resource consumption	I believe I can reduce unnecessary resource consumption in my daily life.	Ajzen (1991); Stern (2000)	Adapted to measure perceived behavioral control over resource-saving practices.
Perceived Behavioral Control	PBC5	Feasibility under current living conditions	I believe that practicing low-carbon behavior is feasible for me under my current living conditions.	Ajzen (1991); Steg & Vlek (2009)	Adapted to measure perceived feasibility and situational control.
Perceived Behavioral Control	PBC6	Control under effort requirement	Even when low-carbon behavior requires extra effort, I believe I can still do it.	Ajzen (1991); Bamberg & Möser (2007)	Adapted to measure perceived control when low-carbon behavior involves effort or inconvenience.
Collective Identity	CI1	Shared group value	I see low-carbon behavior as part of the shared values of university students.	Tajfel & Turner (1979); Fielding & Hornsey (2016)	Adapted to measure whether low-carbon behavior is perceived as a shared value of the student group.
Collective Identity	CI2	Identity consistency	Being low-carbon is consistent with my identity as a responsible university student.	Leach et al. (2008); Fielding & Hornsey (2016)	Adapted to measure consistency between low-carbon behavior and university student identity.
Collective Identity	CI3	Group belonging	I feel a sense of belonging when I participate in low-carbon activities with other students.	Tajfel & Turner (1979); Leach et al. (2008)	Adapted to measure belongingness and emotional connection with the student group.

Table 3. 1 (Continued)

Construct	Code	Measurement Focus	Revised Item in This Study	Main Source(s)	Adaptation Note
Collective Identity	CI4	Identification with low-carbon student group	I identify with university students who regard carbon reduction as a shared responsibility.	Fielding & Hornsey (2016); Fritsche et al. (2018)	Adapted to measure identification with students who share low-carbon responsibility.
Collective Identity	CI5	Desired group membership	Low-carbon behavior reflects the kind of student group I want to belong to.	Tajfel & Turner (1979); Leach et al. (2008)	Adapted to measure group membership preference and identity-based belonging.
Collective Identity	CI6	Connection with environmentally responsible students	Practicing low-carbon behavior makes me feel connected with other environmentally responsible students.	Fielding & Hornsey (2016); Fritsche et al. (2018)	Adapted to measure identity-based connection with environmentally responsible peers.
Carbon Reduction Behavior	CRB1	Actual low-carbon travel behavior	In the past month, I have reduced the use of private cars or ride-hailing services and chosen public transportation, walking, or cycling whenever possible.	Stern (2000); Steg & Vlek (2009)	Revised from intention wording to actual past behavior; adapted to low-carbon travel.
Carbon Reduction Behavior	CRB2	Actual reduction of single-use plastics	In the past month, I have reduced my use of single-use plastic products, such as plastic bags, disposable cups, or plastic straws.	Stern (2000); Steg & Vlek (2009)	Revised to measure actual waste-reduction behavior rather than behavioral intention.
Carbon Reduction Behavior	CRB3	Actual energy-saving behavior	In the past month, I have turned off unnecessary lights, air conditioners, chargers, or other electrical appliances to save energy.	Stern (2000); Steg & Vlek (2009)	Revised to measure actual energy-saving behavior in daily life.
Carbon Reduction Behavior	CRB4	Actual green consumption behavior	In the past month, I have chosen environmentally friendly or low-carbon products when making purchases whenever possible.	Stern (2000); Steg & Vlek (2009)	Revised to measure actual green Consumption behavior.

Table 3. 1 (Continued)

Construct	Code	Measurement Focus	Revised Item in This Study	Main Source(s)	Adaptation Note
Carbon Reduction Behavior	CRB5	Actual recycling and resource-saving behavior	In the past month, I have participated in recycling, waste sorting, or resource-saving activities in my daily life.	Stern (2000); Steg & Vlek (2009)	Revised to measure actual recycling, waste sorting, and resource-saving practices.
Carbon Reduction Behavior	CRB6	General actual carbon reduction behavior	In the past month, I have consciously reduced behaviors that may increase carbon emissions in my daily life.	Stern (2000); Steg & Vlek (2009)	Adapted as a general actual-behavior item covering daily carbon reduction practices.

3.3.8 Translation and Cultural Adaptation Process

Given that the target participants for this research comprised university students residing in Thailand, the survey was constructed in dual English and Thai editions to guarantee precise comprehension among subjects with diverse linguistic origins. The initial questionnaire components were initially formulated in English according to previously established instruments and conceptual models, encompassing the Theory of Planned Behavior (Ajzen, 1991) and Social Identity Theory (Tajfel & Turner, 1979).

To guarantee linguistic precision and conceptual consistency, a dual-translating and back-translation process was implemented. Initially, the English survey was converted into Thai by a bilingual expert possessing expertise in academic investigations and ecological conduct terminology. Following that, a second autonomous bilingual interpreter, who had never examined the primary English document, re-translated the Thai draft back into English. This reversed-translated edition was subsequently contrasted with the initial questionnaire to pinpoint discrepancies in semantic sense, phrasing, and conceptual comprehension.

Several adjustments were made based on the comparison results. For example, abstract expressions related to collective identity and social responsibility were modified into wording that better reflected university students studying in Thailand' daily social experiences. Items measuring subjective norm were carefully revised to emphasize external expectations from peers, teachers, universities, and family members, while

collective identity items focused on internal identification, shared values, and group belonging to avoid conceptual overlap.

In addition, expert consultation was conducted to evaluate the content validity of the questionnaire. Experts with backgrounds in environmental behavior research, sustainability studies, and questionnaire design reviewed the measurement items regarding clarity, relevance, and cultural appropriateness. Based on expert suggestions, several wording modifications were made before the preliminary survey.

Through translation, back-translation, expert evaluation, and pre-survey revision, the final questionnaire was considered culturally appropriate and suitable for measuring carbon reduction behavior among university students studying in Thailand.

3.4 Data Collection Methods

3.4.1 Data Collection Methods

This research employed a survey methodology to gather empirical evidence. The questionnaire framework was developed according to the Theory of Planned Behavior (TPB) and the Theory of Social Identity (SIT), specifically tailored to the context of Thai university students. Data acquisition was performed digitally via tools like Google Forms to guarantee that participants could finish the survey easily and efficiently. The intended demographic for the survey comprised Thai university learners, and the sampling process was primarily focused on institutions across various regions of Thailand to ensure the variability and generalizability of the findings.

3.4.2 Data Collection Process

This research's data gathering procedure was implemented via a systematic digital survey. The survey was constructed according to the study's goals, the Theory of Planned Behavior (TPB), and Social Identity Theory (SIT). TPB offers the conceptual framework for evaluating Attitude, subjective norms, and Perceived Behavioral Control, whereas SIT offers the analytical groundwork for assessing collective identity. Such factors were utilized to interpret carbon reduction practices among Thai university learners. This survey incorporated five fundamental latent constructs: Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction behavior. Every latent construct comprised six questions, leading to a grand total of 30 primary scale questions.

All scale questions were assessed utilizing a seven-point Likert scale spanning from 1 = “strongly disagree” to 7 = “strongly agree.” Utilizing Likert-type scales is suitable for gauging attitudes, perceptions, and behavioral inclinations in social science studies, as it enables participants to articulate various levels of concurrence with particular statements (Likert, 1932). The questionnaire was additionally refined through academic literature analysis, professional input, and pilot survey trials to enhance clarity, content validity, and contextual relevance.

The survey was disseminated primarily via digital platforms to undergraduates across Bangkok, Thailand. As this research targets carbon mitigation practices among Thai university learners, subjects were sourced from diverse academic institutions instead of a solitary school to enhance sample variety and minimize potential bias arising from homogeneity. The electronic survey link was spread through various campus-related digital networks, encompassing student forums, class messaging groups, university social media sites, and additional campus-oriented online platforms. Digital data collection is deemed appropriate for accessing geographically scattered participants rapidly and increasing the operational efficiency of information gathering among student groups (Dillman, Smyth, & Christian, 2014). Prior to initiating the form, subjects were briefed regarding the study objectives, optional involvement, privacy, and the protected nature of their contributions. Such methodological preparations likewise helped mitigate potential common method bias by guaranteeing that participants grasped the scholarly intent of the research and that there were no correct or incorrect responses (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Throughout the data gathering phase, the investigative group tracked the submitted questionnaires and verified if the answers satisfied the specified inclusion standards. Participants were expected to be presently attending Thai university students and falling within the age bracket of 18–30. Following the data gathering process, every completed questionnaire was filtered for thoroughness and authenticity. Surveys were discarded if they included significant missing information, clear straight-line answers, excessively brief completion periods, or logical inconsistencies. For instance, forms with over 10% missing entries in the primary scale factors or those in which nearly every Likert-scale question was responded to with a single choice were deemed invalid. Such filtering protocols were utilized to guarantee data integrity and minimize measurement bias prior

to performing descriptive statistics, reliability assessment, confirmatory factor analysis, and structural equation modeling.

3.4.3 Data Collection Time

The information gathering procedure shall be finished during the next two months. The precise schedule is as follows:

Stage 1 (Weeks 1-2): Develop and refine the survey, perform a preliminary small-scale pilot, and guarantee the questionnaire's efficiency.

Stage 2 (Weeks 3-4): The survey was formally posted online, and information gathering commenced.

Stage 3 (Weeks 5-8): Persist in gathering questionnaires and execute data purification and initial analysis to guarantee the reliability and integrity of the information.

3.4.4 Data Quality Control

To guarantee the dependability and authenticity of the information, this research implemented the subsequent data integrity procedures:

Survey filtering: Throughout the data gathering process, the investigation group shall perform a primary review of every form to guarantee that no blanks, rational flaws, or aberrant responses (e.g., identical selections for all items) exist. Every survey lacking the standards shall be eliminated.

Data sanitization: Following information gathering, the investigation group shall purify the dataset, verifying gaps and anomalies. Regarding surveys containing numerous absent responses, replacement or exclusion will be conducted via mathematical techniques to guarantee the integrity and precision of the records.

Preliminary investigation and modification: Before initiating official information gathering, this research performed a pilot study to guarantee that survey material was lucid and comprehensible, and modified the inquiries and phrasing within the form to ensure its appropriateness for the intended audience.

Data verification: This research employed random sampling to pick a segment of the surveys for subsequent verification to guarantee the genuineness and stability of the survey returns.

3.5 Data Analysis Methods

This research utilized various statistical methodologies to investigate the consistency, authenticity, and systemic associations between the study's variables. The primary goals of the empirical examination were to assess the evaluative precision of the investigative tools, verify the predicted connections between factors, and explore the moderating function of group identification in the development process of climate mitigation actions among undergraduate learners residing in Thailand.

The data evaluation process comprised five primary phases: descriptive statistical examination, consistency and authenticity appraisal, measurement framework assessment, structural equation modeling (SEM), and mediation impact analysis utilizing the Bootstrap technique.

3.5.1 Descriptive Statistical Analysis

To characterize the participant profiles and offer a general view of the research cohort, a descriptive statistical evaluation was performed. This investigation encompassed various sociodemographic factors including sex, age, country of origin, educational qualifications, current academic year, and institutional features.

Frequency counts and proportions were utilized to characterize categorical data, whereas mean values and standard deviations were determined to assess the overall distribution and reaction trends of the research constructs, encompassing behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction practice.

The exploratory evaluation offers essential data concerning the features of the participants and establishes the foundation for following reliability, validity, and structural framework analyses.

3.5.2 Reliability and Validity Testing

To guarantee the precision and authenticity of the evaluation tools, stability and credibility assessments were performed prior to investigating the structural connections between factors.

Internal consistency evaluation was conducted to examine the stability of every construct. The Cronbach's alpha metric was utilized to appraise the reliability of the measurement instruments. Following Nunnally and Bernstein (1994), a Cronbach's alpha score exceeding 0.70 signifies satisfactory internal consistency.

Validity testing consisted of content validity and construct validity.

The content validity was confirmed via a structured literature survey, professional assessment, linguistic translation, and cultural modification steps, plus initial questionnaire trials. Such operations guaranteed that the assessment factors were suitable for investigating carbon mitigation actions among college students attending universities within Thailand.

Construct validity was evaluated via confirmatory factor analysis (CFA). This measurement model was assessed according to factor loadings, composite reliability (CR), and average variance extracted (AVE). Convergent validity was established if factor loadings, CR indices, and AVE scores fulfilled the suggested benchmarks (Hair et al., 2019).

To guarantee that every construct reflected a unique idea, discriminant validity was assessed. The Fornell–Larcker standard was utilized by contrasting the square roots of AVE scores against the correlations among variables (Fornell & Larcker, 1981).

3.5.3 Structural Equation Modeling (SEM)

Structural equation modeling (SEM) was utilized to investigate the proposed associations between behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior.

SEM represents a suitable analytic framework as it enables investigators to concurrently assess various associations between latent variables while accounting for potential measurement inaccuracies. Within this research, SEM was employed to analyze both the measurement structure and the structural framework.

The structural model analysis focused on testing the direct effects of:

Behavioral attitude on carbon reduction behavior;

Subjective norm on carbon reduction behavior;

Perceived behavioral control on carbon reduction behavior;

Collective identity on carbon reduction behavior.

Furthermore, SEM was employed to assess the predictive strength of this study's framework via the coefficient of determination (R^2), reflecting the degree to which the autonomous variables clarify fluctuations in carbon mitigation actions.

Model adequacy was evaluated via standard fit metrics, such as chi-square to degrees of freedom ratio (χ^2/df), comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Such measures were utilized to ascertain if the conceptual framework effectively captured the empirical evidence (Hair et al., 2019; Kline, 2016).

3.5.4 Mediation Effect Test

To investigate the mediating function of collective identity regarding TPB elements and carbon reduction actions, this research utilized the Bootstrap technique.

The Bootstrap technique is extensively advised for assessing indirect impacts since it does not necessitate the presumption of normality for mediating effects and offers more precise evaluation of mediation impacts (Preacher & Hayes, 2008; Hayes, 2018).

Within this research, 5,000 Bootstrap iterations were performed to assess the mediated impacts of:

Behavioral attitude → Collective Identity → Carbon Reduction Behavior;

Subjective norm → Collective Identity → Carbon Reduction Behavior;

Perceived behavioral control → Collective Identity → Carbon Reduction Behavior.

To assess whether the mediation effect was statistically meaningful, we evaluated whether the 95% Bootstrap confidence interval excluded zero. This specific methodology was employed to examine if collective identity functioned as a psychological intermediary whereby personal cognition and societal pressure were translated into genuine practices of carbon mitigation.

3.5.5 Data Analysis Procedure

The data examination process adhered to a structured framework to guarantee procedural integrity.

Initially, information filtering and purification were carried out to recognize missing entries, irregular answer sequences, and faulty surveys. Following the data organization, exploratory quantitative evaluation was executed to investigate participant profiles and the general prevalence of study factors.

Furthermore, reliability and validity evaluations were performed to assess the quality of the measurement tools. Cronbach's alpha served to measure internal consistency, whereas confirmatory factor analysis was carried out to examine factor loadings, composite reliability, convergent validity, and discriminant validity.

Thirdly, structural equation modeling was utilized to examine the presumed direct correlations between behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior. Model fit indices plus explanatory power were analyzed to assess the appropriateness of the suggested structural framework.

Ultimately, the Bootstrap technique involving 5,000 iterations was utilized to evaluate the mediating role of collective identity. The importance of indirect impacts was assessed by checking if the confidence intervals contained zero.

Utilizing this evaluative approach, the research methodically investigated the suggested conceptual framework and offered quantitative proof concerning the mental and communal drivers for carbon mitigation actions among college learners residing in Thailand.

3.6 Scale Format and Pre-survey

3.6.1 Scale Format

To guarantee the academic precision and dependability of the survey construction, this research utilized a seven-item Likert format to evaluate every latent construct. The Likert scale is extensively utilized in social scientific investigations since it efficiently assesses participants' impressions, opinions, convictions, and conduct inclinations regarding particular assertions.

Within this research, every assessment component was evaluated utilizing a seven-level Likert scale spanning from 1 ("completely disagree") to 7 ("completely agree"). This seven-tier structure was chosen since it offers adequate feedback diversity and enables participants to convey various degrees of concordance concerning their subjective views and actions.

Every latent variable, encompassing behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior, was assessed utilizing this specific format. Every construct comprised several items derived

from earlier verified instruments. Prior to the official data gathering, the survey underwent scrutiny via literature review, expert assessment, translation and cultural modification processes, and initial trials to guarantee content relevance and measurement consistency.

3.6.2 Preliminary Investigation

Prior to initiating the official survey, an initial probe was performed to assess the lucidity, interpretability, and cultural suitability of the research instrument. The objective of this exploratory phase was to guarantee that Thai university students could precisely grasp the evaluation indicators and that the survey materials aligned with the primary research goals.

The initial research aimed at pinpointing vague phrasing, indistinct statements, duplicated inquiries, and potential cross-cultural misinterpretations. Special focus was placed on elements concerning subjective norm, collective identity, and carbon mitigation actions since these concepts entail societal pressures, group affiliation, and routine ecological activities.

3.6.2.1 Preliminary Survey Process

Before the official research began, an initial study was performed on Thai university learners. This phase aimed to assess whether the survey questions were clear, culturally relevant, and appropriate for the intended participants.

A total of 50 individuals were chosen from the intended group for the initial study. These subjects embodied varied origins, encompassing various institutions, academic levels, disciplines, sexes, and ethnicities, enabling the investigators to gather insights from a fairly heterogeneous student cohort.

The survey was circulated digitally, and participants were requested to fill out every section based on their personal views and carbon-cutting actions. The typical duration of filling out was roughly 10 to 15 minutes.

Throughout the initial investigation, participants were encouraged to offer insights concerning ambiguous phrasing, challenging language, redundant questions, and culturally sensitive phrasing. Special focus was directed toward the assessment factors of subjective norm and collective identity, as these specific constructs involve distinct psychological processes. Subjective norm questions were scrutinized to guarantee that they captured perceived external pressures from significant others, whereas collective

identity questions were analyzed to ensure that they embodied internal belonging, common beliefs, and group affiliation.

According to participant input, various minor refinements were implemented. Initially, intricate academic terminologies were streamlined to enhance clarity. Furthermore, multiple queries were modified to more accurately capture the everyday vernacular and realities of Thai university learners. Additionally, the differentiation between subjective norm and collective identity was more distinctly clarified to prevent theoretical confusion. Ultimately, carbon mitigation action elements were rephrased to highlight genuine low-emission activities instead of solely focusing on behavioral intentions.

Upon finishing these adjustments, the survey was deemed appropriate for the preliminary evaluation.

3.6.2.2 Pilot Test of the Questionnaire

Following the initial investigation and refinement of the survey, a pilot study was performed to assess the consistency and initial credibility of the amended instrument.

For this research, 50 reliable questionnaires were utilized in the preliminary phase. This pilot survey comprised 30 evaluative items addressing five frameworks: behavioral intention, subjective norm, perceived behavioral control, collective identity, and carbon mitigation actions. Every construct was assessed through six questions utilizing a seven-point Likert rating scale.

As displayed in Table 3-2, the general Cronbach's alpha value for the survey reached 0.927. This metric is extensively utilized to assess the internal consistency reliability of various measurement instruments (Cronbach, 1951). Per Nunnally and Bernstein (1994), a Cronbach's alpha figure exceeding 0.70 reflects acceptable reliability, whereas scores over 0.90 signify superior internal consistency. Consequently, the pilot study outcomes indicated that the instrument possessed outstanding reliability and that its individual items exhibited robust internal consistency.

Furthermore, Kaiser-Meyer-Olkin (KMO) sampling adequacy and Bartlett's Test of Sphericity were performed to determine if the pilot sample was appropriate for factor analysis. The KMO statistic was 0.755, surpassing the suggested minimum of 0.70, suggesting satisfactory sampling adequacy (Kaiser, 1974). Additionally, Bartlett's Test of Sphericity showed a significant result ($\chi^2 = 1017.331$, $df = 435$, $p < .001$), demonstrating

that the correlation matrix deviated substantially from an identity matrix and that adequate intercorrelations existed between the measurement variables (Bartlett, 1954).

In summary, the findings from the pilot phase verified that this survey exhibited adequate consistency and initial credibility. The acceptable alpha coefficient, KMO metric, and the substantial Bartlett's Test of Sphericity outcomes suggested that the assessment factors were suitable for subsequent quantitative investigation.

Consequently, the modified survey was preserved for actual information gathering. The complete dataset was then utilized for consistency evaluation, confirmatory factor examination, structural equation modeling, and Bootstrap mediation testing.

Table 3. 2 Pilot Test Reliability and Validity Results

Test	Value
Number of respondents	50
Number of items	30
Cronbach's Alpha	0.927
KMO Measure of Sampling Adequacy	0.755
Bartlett's Test of Sphericity: Approx. Chi-Square	1017.331
df	435
Sig.	0.000

3.6.3 Questionnaire Revision and Final Design

Drawing upon the insights gathered via the initial study and the outcomes of the trial phase, the survey was subsequently polished prior to actual information gathering.

First, language simplification was conducted. Several complex academic expressions were modified into clearer and more understandable statements to ensure that respondents could accurately interpret the meaning of each item.

Second, cultural adaptation adjustments were conducted. Considering the multicultural environment of Thai higher education institutions, several expressions were modified to better reflect the daily experiences and social contexts of university students studying in Thailand.

Third, construct distinction adjustments were implemented. The measurement items of subjective norm were refined to emphasize external social expectations from peers, family members, universities, and other important groups. Meanwhile, collective identity items were revised to focus on internal group identification, shared environmental values, and collective responsibility.

Finally, behavioral measurement refinement was conducted. Carbon reduction behavior items were adjusted to measure actual low-carbon practices, including energy conservation, low-carbon transportation, and green consumption behaviors, rather than only behavioral intention.

Following these modifications, the ultimate survey comprised five primary constructs: behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior. Every construct included six evaluative items, leading to a total of 30 assessment points measured via a seven-point Likert scale. This refined questionnaire was deemed suitable for rigorous data gathering and the subsequent structural model evaluation.

CHAPTER 4
DATA ANALYSIS AND RESULTS

4.1 Overview of Data Analysis

This section demonstrates the empirical findings derived from the questionnaire investigation. Grounded in the investigative goals and assumptions formulated in preceding sections, the statistical evaluation concentrates on investigating the correlations between Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction practices among Thai university students. Specifically, this paper seeks to verify if the three pillars of the Theory of Planned Behavior exert a direct impact on carbon reduction activities, and whether collective identity serves as a mediating mechanism in the shift from personal psychological variables toward tangible low-carbon behaviors.

Prior to performing rigorous statistical evaluation, the gathered survey information underwent initial filtering and purification. Unqualified questionnaires were discarded based on the standards defined within Chapter 3, encompassing excessive blank entries, evident straight-lining behaviors, implausibly brief completion durations, and logical inconsistencies. Following data cleansing, the legitimate replies were brought into SPSS and AMOS for subsequent examination. SPSS primarily served for descriptive metrics, consistency testing, and initial dataset sorting, whereas AMOS was utilized for confirmatory factor examination, structural equation modeling, and mediation impact assessment.

The data evaluation within this section is structured into various phases. Initially, descriptive statistical examination was performed to synthesize the demographic features of the participants, encompassing gender, age, educational background, year of enrollment, academic discipline, university classification, engagement in ecological courses, involvement in green clubs or charitable work, awareness of carbon offsetting practices, and origins of carbon mitigation data. Regarding categorical demographic factors, counts

and proportions were provided. For multi-select questions, like the primary pathways through which participants acquired carbon offsetting knowledge, multiple response evaluation was executed to determine the occurrence and percentage for every category.

Furthermore, descriptive analytics were performed on the primary study variables, encompassing Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction actions. As all latent constructs were assessed through a seven-item Likert scale, the average and standard deviation for every construct were determined to evaluate the general magnitude and dispersion of participants' views, perceptions, identity, and real low-carbon conduct. Skewness and kurtosis were additionally utilized to determine whether the dataset roughly satisfied the normality prerequisites for following structural equation modeling.

Third, reliability and validity assessments were performed to appraise the quality of the measurement framework. Cronbach’s alpha was utilized to determine the internal consistency of every construct. Confirmatory factor analysis was subsequently carried out to investigate whether the manifest items loaded significantly onto their respective latent variables. Convergent validity was assessed according to standardized factor loadings, composite reliability, and average variance extracted. Discriminant validity was evaluated by comparing the square root of AVE with the correlations between constructs.

Fourthly, structural equation modeling was employed to verify the proposed associations between these factors. The immediate impacts of Attitude, subjective norms, Perceived Behavioral Control, and collective identity on carbon reduction actions were investigated. Furthermore, the influences of Attitude, subjective norms, and Perceived Behavioral Control on collective identity were likewise analyzed. Model fit was assessed utilizing frequently recognized fit statistics, such as χ^2/df, CFI, TLI, RMSEA, and SRMR.

Ultimately, the Bootstrap procedure was employed to investigate the mediating function of collective identity. The mediating impacts were assessed by calculating the indirect influences of Attitude, subjective norms, and Perceived Behavioral Control on carbon reduction actions via collective identity. If the 95% confidence interval for an indirect effect excluded zero, the mediation impact was deemed statistically meaningful. Through these evaluations, this section offers empirical proof for appraising the suggested theoretical framework and identifying if the study hypotheses are validated.

4.2 Descriptive Statistical Analysis

Table 4. 1 Descriptive Statistical Analysis

Variable	Options	Frequency	Percentage
University	Mahidol University	62	17.9
	Chulalongkorn University	52	15.0
	Bangkok University	40	11.5
	Dhurakij Pundit University	34	9.8
	Krirk University	33	9.5
	Thammasat University	22	6.3
	Kasetsart University	21	6.1
	Bangkok Thonburi University	19	5.5
	Stamford International University	18	5.2
	Srinakharinwirot University	17	4.9
	Silpakorn University	13	3.7
	Assumption University	11	3.2
	Rajamangala University of Technology Rattanakosin	5	1.4
Participation in Environmental or Sustainability-related Courses	No	102	29.4
	Yes	245	70.6
Participation in Environmental Groups or Volunteer Activities	No	87	25.1
	Yes	260	74.9
Gender	Male	157	45.2
	Female	190	54.8
Age	18	57	16.4
	19	67	19.3
	20	72	20.7
	21	63	18.2
	22	23	6.6
	23	16	4.6
	24	27	7.8
	25	14	4.0
	26	8	2.3
Academic Year	Freshman	63	18.2
	Sophomore	73	21.0
	Junior	75	21.6
	Senior	73	21.0
	Graduate Student	63	18.2
Nationality	Thailand	139	40.1
	China	208	59.9

Table 4.1 (Continued)

Variable	Options	Frequency	Percentage
Major Type	Science/Engineering	84	24.2
	Business	92	26.5
	Sports/Arts	32	9.2
	Humanities	91	26.2
	Medicine	48	13.8
Are you familiar with carbon reduction behaviors?	A. Very familiar with it	89	25.6
	B. Have a good understanding of it	158	45.5
	C. I've heard of it, but I don't know the specifics.	54	15.6
	D. Never heard of it before	46	13.3
What are the main channels for learning about carbon emission reduction efforts? (Multiple selections allowed)	A. School Curriculum/Classroom Learning (Reading, Textbooks, Teacher Lectures)	188	19.5%
	B. Campus Publicity/Regulations (Posters, Notices, Waste Sorting and Energy Saving Tips, etc.)	180	18.7%
	C. Social Media/Short Video Platforms (e.g., Facebook/Instagram/ TikTok, etc.)	83	8.6%
	D. Forums/Communities/Online Communities (e.g., Reddit, Line Groups, School Community, etc.)	163	16.9%
	E. Environmental Protection Clubs/Volunteer Activities/Campus Greening Activities	172	17.8%
	F. Communication with Family/Friends/Peers	83	8.6%
	G. News Media/Government or Institutional Publicity	96	9.9%

This segment displays the descriptive analytical outcomes concerning the sample demographics. As depicted in Table 4.1 a cumulative 347 legitimate questionnaires were gathered for this research. The descriptive evaluation primarily encompasses university locations, involvement in ecological or sustainable-oriented classes, engagement in environmental organizations or charitable work, gender, age, academic standing, nationality, field of study, awareness of carbon mitigation actions, and data channels regarding carbon reduction.

Regarding the university spread, participants were sourced from various Thai institutions, suggesting that the selection was dispersed across several campuses. Specifically, Mahidol University possessed the highest participant count, with 62 students, representing 17.9% of the entire group. Subsequently, Chulalongkorn University featured 52 subjects, making up 15.0%, while Bangkok University included 40 individuals, reaching 11.5%. Dhurakij Pundit University comprised 9.8%, Krirk University included 9.5%, and Thammasat University included 6.3%. Additional institutions, such as Kasetsart University, Bangkok Thonburi University, Stamford International University, Srinakharinwirot University, Silpakorn University, Assumption University, and Rajamangala University of Technology Rattanakosin, likewise participated. This demonstrates that the cohort encompassed students from diverse academic environments, thereby enhancing the representativeness of the data.

Concerning engagement in ecological or green-oriented programs, 245 participants indicated they had enrolled in these classes, representing 70.6% of the entire group, whereas 102 individuals did not engage, making up 29.4%. This suggests that a majority of the subjects possessed certain academic training regarding ecological conservation, carbon neutrality, or sustainable themes. Such instructional background might offer a mental foundation for learners to grasp low-carbon actions and ecological accountability.

Regarding involvement in ecological organizations or charitable endeavors, 260 participants indicated they engaged in environmental groups or pro-bono work, representing 74.9% of the total sample. Simultaneously, 87 individuals stated they abstained from these initiatives, totaling 25.1%. This finding implies that a significant number of subjects possessed hands-on experience concerning ecological conservation. Such involvement might assist in bolstering pupils' ecological consciousness, communal sense, and genuine participation in carbon mitigation actions.

Regarding the sex ratio, 157 participants identified as male, representing 45.2%, whereas 190 subjects identified as female, making up 54.8%. The percentage of female participants was marginally greater than that of male subjects, yet the total gender makeup remained fairly equitable. Consequently, this dataset offers a valid foundation for examining low-carbon activities among pupils of diverse sexes.

Concerning age demographics, participants were primarily clustered within the 18 to 21-year-old range. More precisely, students turning 20 comprised the most significant group, with 72 individuals representing 20.7%. This was exceeded by those who were 19, including 67 participants or 19.3%; those who turned 21, including 63 subjects or 18.2%; and those who were 18, including 57 individuals or 16.4%. Collectively, respondents aged 18 through 21 made up 74.6% of the entire population. This demonstrates that the participants largely consisted of conventional college-age learners, which aligns with the study's emphasis on college students.

Regarding the academic term, the survey participants' allocation remained fairly equitable. Sixty-three first-years comprised 18.2%; seventy-three second-years made up 21.0%; seventy-five third-years represented 21.6%; seventy-three fourth-years occupied 21.0%; and sixty-three postgraduate students constituted 18.2%. The ratios of various academic levels were nearly identical, suggesting that the group included learners from diverse phases of college training. This ensures that the findings are less likely to be influenced by a single particular scholarly year cohort.

Concerning citizenship, 208 participants were Chinese learners, representing 59.9%, whereas 139 individuals were Thai learners, making up 40.1%. This outcome demonstrates that the group comprised both Chinese and Thai pupils attending Thai institutions. The integration of learners from diverse ethnic origins might offer a more extensive viewpoint for grasping carbon mitigation practices within Thai college environments.

Regarding primary categories, participants originated from diverse academic fields. Students majoring in business represented the highest percentage, with 92 participants, making up 26.5%. This was succeeded by those in humanities, featuring 91 individuals, representing 26.2%, and science or engineering fields, involving 84 persons, totaling 24.2%. Medical-related disciplines made up 13.8%, whereas sports and arts programs comprised 9.2%. Collectively, this dataset encompassed numerous educational foundations, which is beneficial for investigating whether eco-friendly actions occur throughout various areas of learning.

Concerning the awareness of carbon reduction actions, 89 participants indicated they possessed high familiarity, representing 25.6%, whereas 158 individuals expressed a solid comprehension, making up 45.5%. Combined, these two categories constituted

71.1% of the entire sample. Furthermore, 54 subjects mentioned that they were acquainted with carbon reduction practices but lacked specific details, making up 15.6%, while 46 participants had never encountered it prior, totaling 13.3%. Such findings suggest that the majority of subjects possessed a particular degree of insight or consciousness regarding carbon reduction activities, which offers a favorable foundation for further exploration of attitudes, norms, perceived behavioral control, collective identity, and real carbon reduction conduct.

Regarding the multi-option inquiry concerning primary pathways for participants' knowledge of carbon neutrality, the predominant source identified was school-based curricula or classroom instruction, receiving 188 votes. This suggests that institutional schooling remained a crucial conduit for learners to gain insights into carbon mitigation. Campus advertising and institutional policies garnered second place, with 180 votes, implying that university flyers, announcements, recycling education, and power conservation advice likewise performed a vital function in disseminating carbon neutrality data. Green campus groups, charitable work, and ecological enhancement projects were chosen 172 times, demonstrating that tangible environmental initiatives were likewise a significant information resource. Online forums, social groups, and virtual networks were selected 163 times, whereas traditional media or official departmental promotion were chosen 96 times. Social networking sites or brief video portals and interaction with relatives, acquaintances, or colleagues were both counted 83 times. Generally, these findings indicate that school-centered tracks, campus promotion, and ecological hands-on exercises were the primary methods for pupils to understand carbon neutrality.

In summary, the summary statistics demonstrate that the participants exhibited a considerable variety regarding their academic origins, current grade level, primary majors, and prior environmental exposure. The majority of the subjects had engaged in ecological or green-focused classes and ecological clubs or charitable work, and nearly all possessed some level of awareness about carbon mitigation actions. Such attributes imply that this cohort is appropriate for investigating the mental and societal elements impacting carbon lowering practices within college students. These descriptive outcomes further establish a basis for following up with consistency evaluation, authenticity verification, structural equation modeling, and mediating impact assessment.

Table 4. 2 Descriptive Statistics of Measurement Items and Dimensions

Dimension	Item	Item Mean	Item Std. Deviation	Dimension Average Mean	Average Std. Deviation
Attitude (ATT)	ATT1	4.401	1.646	4.456	1.330
	ATT2	4.524	1.626		
	ATT3	4.409	1.597		
	ATT4	4.519	1.601		
	ATT5	4.380	1.744		
	ATT6	4.504	1.661		
Subjective Norms (SN)	SN1	4.245	1.678	4.312	1.336
	SN2	4.334	1.699		
	SN3	4.320	1.545		
	SN4	4.300	1.630		
	SN5	4.329	1.702		
	SN6	4.346	1.647		
Perceived Behavioral Control	PBC1	4.392	1.621	4.356	1.315
	PBC2	4.380	1.625		
	PBC3	4.323	1.571		
	PBC4	4.360	1.683		
	PBC5	4.329	1.631		
	PBC6	4.352	1.610		
Collective Identity (CI)	CI1	4.262	1.625	4.257	1.280
	CI2	4.280	1.543		
	CI3	4.228	1.601		
	CI4	4.173	1.676		
	CI5	4.349	1.651		
	CI6	4.251	1.596		
Carbon Reduction Behavior (CRB)	CRB1	4.435	1.607	4.323	1.268
	CRB2	4.317	1.635		
	CRB3	4.176	1.588		
	CRB4	4.329	1.540		
	CRB5	4.380	1.571		
	CRB6	4.300	1.638		

According to Table 4.2, descriptive statistics for the measurement indicators and dimensions were computed to assess the general response inclination of the primary research variables. Every construct was evaluated using six questions on a seven-level Likert scale extending from 1 = strongly disagree to 7 = strongly agree. Likert-style scales are frequently utilized to gauge participants' viewpoints, perceptions, and conduct patterns by enabling them to express various levels of concurrence with a sequence of statements (Likert, 1932; Sullivan & Artino, 2013). Consequently, the average mean for each dimension was determined by averaging the six questions within every construct, ensuring that the findings could be analyzed on the identical 1–7 range as the initial questionnaire questions.

When several Likert-scale questions are integrated to evaluate a single construct, the aggregated scale can be described via the mean and standard deviation, assuming that the factors jointly exhibit sufficient reliability and assess the identical fundamental concept (Norman, 2010; Sullivan & Artino, 2013). Within this research, the consistency and confirmatory factor analysis findings verified that the six questions in every construct showed adequate internal reliability and structural validity. Consequently, employing the mean scores and standard deviations was suitable for aggregating participants' general levels of Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction behavior.

To aid in understanding, the average ratings were categorized into five tiers by partitioning the potential seven-point interval into five identical segments. The specific interval breadth was determined through this method: $(7 - 1) / 5 = 1.20$ Consequently, mean values between 1.00 and 2.20 were considered very low, 2.21 and 3.40 as low, 3.41 and 4.60 as moderate, 4.61 and 5.80 as high, and 5.81 and 7.00 as very high. This grouping was utilized as a descriptive analytical structure for this research. It was employed to demonstrate the comparative standing of every dimension mean across the seven-point feedback range instead of indicating statistical importance. Thus, the mean categories must not be regarded as proof that one variable was numerically greater or lesser than another without further inferential evaluation.

Regarding Attitude (ATT), item mean scores fluctuated between 4.380 and 4.524, while the mean for the dimension stood at 4.456, possessing a mean standard deviation of 1.330. Based on the mean-level interpretation standards, this attitude was categorized as

moderate. It exhibited the highest average mean across the five dimensions, suggesting that participants typically maintained moderately favorable views on carbon reduction actions. Put differently, the majority of students tended to concur that carbon reduction efforts were significant, advantageous, and worth implementing. Nevertheless, since the dimension average mean failed to surpass 4.60, this attitude level should not be misinterpreted as high.

Employing the average and standard deviation to characterize this construct is suitable since ATT was assessed via six interconnected items instead of a single Likert-type item. Sullivan and Artino (2013) observed that while each individual Likert item is ordinal, a composite scale generated from multiple related questions is frequently summarized utilizing means and standard deviations. Norman (2010) additionally contended that parametric descriptive techniques are typically robust when applied appropriately to Likert-scale data.

Regarding subjective norms (SN), the item mean scores varied between 4.245 and 4.346. The mean across all dimensions reached 4.312, accompanied by a mean standard deviation of 1.336. This figure resides in the moderate range. The findings suggest that participants recognized a moderate intensity of societal pressure and backing from significant individuals, including peers, buddies, instructors, campus personnel, and kin. Consequently, social pressure existed within the subjects' everyday surroundings; however, the typical degree of perceived normative pressure had not yet attained the upper classification.

The mean standard deviation of 1.336 further demonstrates that participants' evaluations were distributed across the average value. Certain pupils might have felt intense motivation and anticipation within their societal context, while others encountered comparatively minimal regulative assistance. This measure reflects the degree to which feedback fluctuates around the central point and must thus be considered alongside the average instead of being viewed as an independent assessment of the latent variable level.

Regarding Perceived Behavioral Control (PBC), the item mean scores varied between 4.323 and 4.392. The mean value for this dimension was 4.356, while the mean standard deviation was 1.315. Following the specified criteria for interpretation, Perceived Behavioral Control was categorized as moderate. This indicates that participants typically

perceived themselves as having a sufficient level of capacity, assets, and prospects to engage in low-carbon activities.

The findings further suggest that learners regarded measures like power conservation, eco-friendly spending, low-impact travel, and resource minimization as moderately viable within their everyday routines. However, since the average score stayed under the upper boundary of 4.61, this outcome implies that certain pupils might still encounter tangible constraints concerning facilities, expenses, ease, ecological awareness, or availability of sustainable options.

Regarding collective identity (CI), the individual item means varied between 4.173 and 4.349. The mean across all dimensions was 4.257, accompanied by a mean standard deviation of 1.280. This figure was categorized as a moderate level and reflected the minimum mean value for all five constructs.

The findings suggest that participants exhibited a moderate level of alignment regarding carbon mitigation as a component of shared academic principles and communal duty. While group identity was somewhat less than Attitude and Perceived Behavioral Control, it must not be perceived as deficient since the rating stayed above the center of the scale and in the moderate range. Instead, this result implies that identity-driven comprehension of carbon mitigation was already existing in subjects but still possessed potential for additional enhancement.

Regarding carbon reduction activities (CRB), item mean scores fluctuated between 4.176 and 4.435. The mean across all dimensions was 4.323, featuring a mean standard deviation of 1.268. Based on the specified interpretation scale, carbon reduction behavior was categorized as moderate. This suggests that participants expressed participating in real carbon reduction practices at a moderate degree within their everyday routines.

Regarding the CRB factors, CRB1 exhibited the peak average score, implying that participants demonstrated greater engagement in the specific low-carbon practices. Nevertheless, since the general mean across dimensions stayed under the upper boundary of 4.61, this finding further suggests that there exists potential to motivate pupils to convert their ecological consciousness and shared sense of belonging into more habitual, steady, and repetitive low-carbon activities.

In total, each of the five factors was categorized as moderate, with the mean scores for every dimension exceeding the central point of the seven-item Likert scale. This indicates that participants typically exhibited moderately favorable opinions, average perceived social backing, average perceived action viability, average group affiliation, and a moderate degree of real engagement in carbon mitigation activities.

Regarding these five aspects, Attitude exhibited the greatest mean score, followed by Perceived Behavioral Control, carbon reduction actions, subjective norms, and collective identity. Such ordering reflects the approximate descriptive hierarchy of these constructs throughout the participants. Nonetheless, the quantitative variations between the five means were minimal and must not be regarded as statistically meaningful distinctions until further inferential analysis is conducted.

The average-level results initially indicate that participants' personal ecological assessments were generally more robust than their collective association with carbon mitigation. Nonetheless, basic descriptive metrics are insufficient for identifying causal links or meaningful variations between these variables. Their primary function is to characterize the typical values and data spread within the population, whereas structural equation modeling is essential for evaluating if these factors substantially affect carbon mitigation practices.

From a pragmatic viewpoint, these findings imply that academic institutions must persist in reinforcing pupils' personal ecological viewpoints and perceived practical capacities while placing more focus on cultivating communal self-identification, common institutional virtues, and joint accountability concerning carbon mitigation. Nevertheless, such operational suggestions ought to be understood alongside the structural framework and mediating outcomes instead of relying merely on the summary average ratings.

Table 4. 3 Comparison of Core Constructs Between Thai and Chinese Students

Construct	Thai Students (n=139) Mean (SD)	Chinese Students (n=208) Mean (SD)	t-value	p-value
Behavioral Attitude (ATT)	4.530 (1.289)	4.407 (1.358)	0.852	0.395
Subjective Norm (SN)	4.465 (1.339)	4.210 (1.327)	1.746	0.082
Perceived Behavioral Control (PBC)	4.378 (1.383)	4.341 (1.271)	0.248	0.805

Table 4. 3 (Continued)

Construct	Thai Students (n=139) Mean (SD)	Chinese Students (n=208) Mean (SD)	t-value	p-value
Collective Identity (CI)	4.273 (1.289)	4.246 (1.277)	0.195	0.846
Carbon Reduction Behavior (CRB)	4.526 (1.224)	4.187 (1.282)	2.486	0.013

To thoroughly investigate whether disparities existed among Thai domestic learners and Chinese overseas students, an independent samples t-test was performed to evaluate the mean variances of the five primary constructs.

According to Table 4.3, Thai learners typically exhibited slightly larger average scores compared to their Chinese counterparts regarding every dimension, encompassing behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior.

The findings revealed that no statistically meaningful disparities existed between Thai and Chinese pupils concerning behavioral orientation ($t = 0.852$, $p = 0.395$), subjective norm ($t = 1.746$, $p = 0.082$), perceived behavioral control ($t = 0.248$, $p = 0.805$), or collective identity ($t = 0.195$, $p = 0.846$). Such results imply that learners from both cultural backgrounds exhibited quite comparable psychological viewpoints toward carbon mitigation and group-based environmental affiliation.

Nevertheless, a substantial disparity was noted regarding carbon mitigation actions between Thai and Chinese pupils ($t = 2.486$, $p = 0.013$). Thai learners exhibited greater degrees of real carbon reduction activities ($M = 4.526$, $SD = 1.224$) than Chinese counterparts ($M = 4.187$, $SD = 1.282$). This result indicates that while both cohorts possessed comparable views, social impressions, perceived capability, and communal solidarity regarding carbon reduction, variations occurred in the conversion of ecological awareness into tangible low-carbon habits.

4.3 Reliability Analysis

To investigate the internal consistency of the measurement framework, reliability analysis was performed. Within this research, Cronbach's alpha was employed to assess the reliability for every construct, encompassing Attitude, subjective norms, Perceived

Behavioral Control, collective identity, and carbon reduction behavior. Cronbach's alpha represents a frequently utilized coefficient for evaluating the internal consistency of multi-item measurement scales (Cronbach, 1951). Generally, a Cronbach's alpha score exceeding 0.70 suggests acceptable internal consistency, whereas scores over 0.80 signify high reliability (Nunnally & Bernstein, 1994; Hair, Black, Babin, & Anderson, 2014).

Table 4. 4 Reliability Analysis Analysis

Dimensions	**Topic**	**Cronbach's Alpha after deleting items**	**Cronbach's Alpha**	**TotalCronbach's Alpha**
Attitude	ATT1	0.922	0.894	0.924
	ATT2	0.921		
	ATT3	0.921		
	ATT4	0.922		
	ATT5	0.921		
	ATT6	0.922		
Subjective Norms	SN1	0.921	0.895	
	SN2	0.922		
	SN3	0.922		
	SN4	0.922		
	SN5	0.921		
	SN6	0.921		
Perceived Behavioral Control	PBC1	0.922	0.895	
	PBC2	0.922		
	PBC3	0.922		
	PBC4	0.922		
	PBC5	0.921		
	PBC6	0.922		
Collective Identity	CI1	0.921	0.881	
	CI2	0.922		
	CI3	0.922		
	CI4	0.922		
	CI5	0.922		
	CI6	0.923		
Carbon Reduction Behavior	CRB1	0.922	0.883	
	CRB2	0.923		
	CRB3	0.922		
	CRB4	0.923		
	CRB5	0.922		
	CRB6	0.922		

As illustrated in Table 4.4, the Cronbach's alpha coefficients for each of the five constructs exceeded 0.80. Precisely, the Cronbach's alpha for Attitude reached 0.894, reflecting excellent internal reliability among the six associated attitude questions. The Cronbach's alpha for subjective norms stood at 0.895, confirming that the six indicators assessing perceived societal pressures and encouragement were highly dependable. Similarly, the Cronbach's alpha for Perceived Behavioral Control was 0.895, indicating that the factors evaluating pupils' perceived capacity and practicality to engage in low-carbon activities exhibited robust consistency. Furthermore, the Cronbach's alpha for collective identity was 0.881, while that for carbon reduction behavior was 0.883, both surpassing the suggested limit and showcasing superior internal reliability.

The comprehensive Cronbach's alpha coefficient for the entire instrument amounted to 0.924, reflecting superior internal consistency across the 30 evaluative components. Additionally, the "Cronbach's alpha if item deleted" scores fluctuated between 0.921 and 0.923, and no item-exclusion statistic was significantly greater than the initial Cronbach's alpha figure. This implies that no single question severely diminished the stability of the complete framework. Consequently, every assessment variable was preserved for following validity assessment, confirmatory factor analysis, structural equation modeling, and mediation effect evaluation.

To summarize, the outcomes of reliability assessment demonstrate that the evaluation instrument utilized here possesses excellent internal consistency and is appropriate for subsequent empirical investigation.

4.4 Validity Analysis

Prior to performing factor analysis, the Kaiser-Meyer-Olkin (KMO) sampling adequacy measure and Bartlett's test of sphericity were employed to evaluate whether the dataset was appropriate for factor extraction. The KMO statistic is utilized to determine whether the intercorrelations among variables are adequate for factor extraction. Generally, a KMO score exceeding 0.70 is considered acceptable sampling adequacy, whereas a score greater than 0.90 suggests superior suitability for factor analysis (Kaiser, 1974; Hair, Black, Babin, & Anderson, 2014). Bartlett's test of sphericity was utilized to ascertain whether

the correlation matrix differed significantly from an identity matrix, which is essential prior to executing factor analysis (Bartlett, 1954).

Table 4. 5 KMO and Bartlett tese

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.926
Bartlett's Test of Sphericity	Approx. Chi-Square	5635.064
	df	435
	Sig.	0.000

According to Table 4.5, the KMO statistic for this research was 0.926, exceeding the suggested minimum of 0.90. This demonstrates that the dataset possessed superior suitability for conducting factor analysis. Furthermore, the Bartlett's test of sphericity yielded a statistically significant result, featuring a computed chi-square statistic of 5635.064, df = 435, and $p < 0.001$. Such findings suggest that the correlation matrix was not identical to the identity matrix and that substantial intercorrelations existed among the various measurement variables.

Consequently, the outcomes of the KMO and Bartlett's tests indicate that the dataset was suitable for proceeding with factor analysis. This offers a quantitative foundation for performing exploratory factor analysis and following confirmatory factor analysis.

4.5 Confirmatory Factor Analysis (CFA)

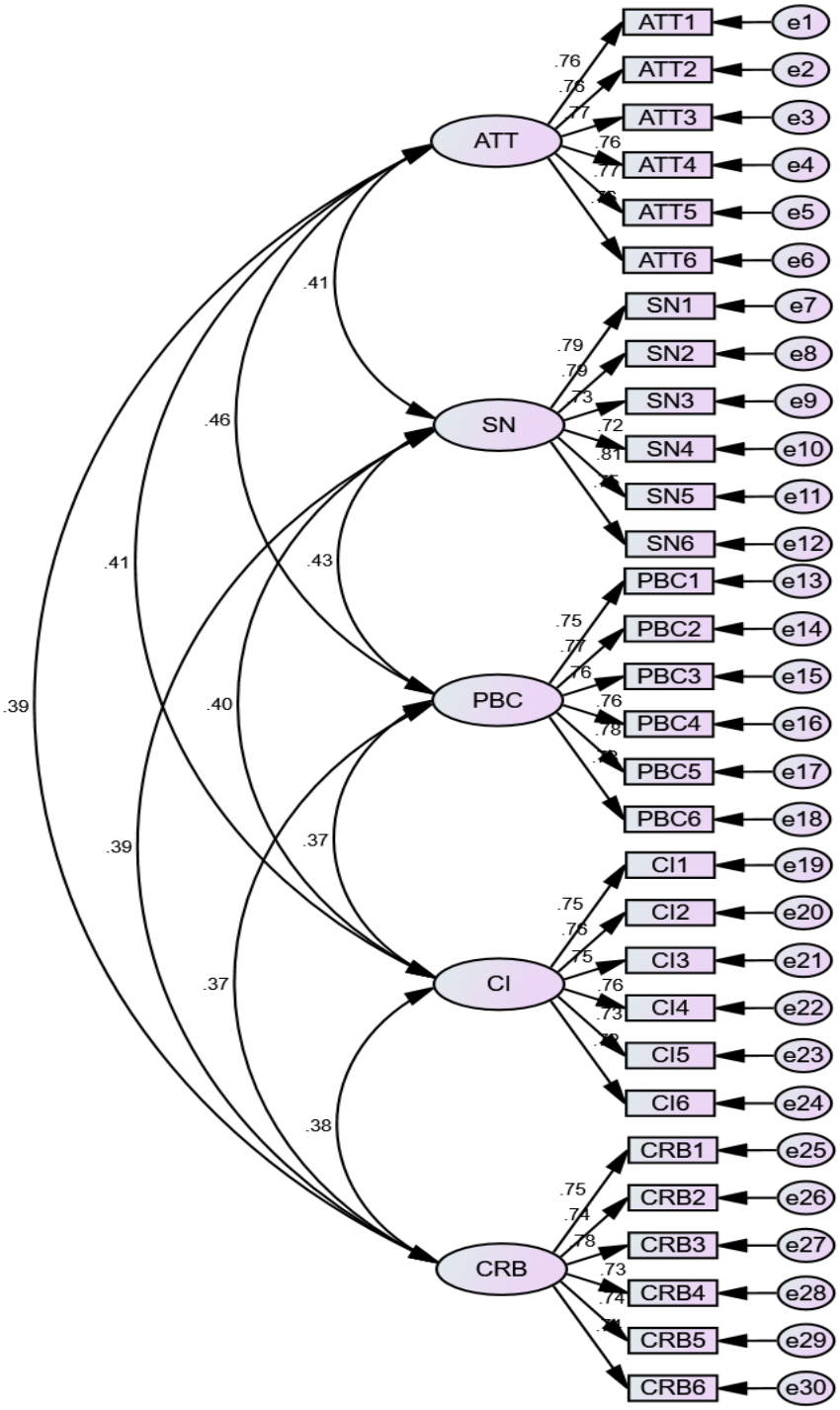

Figure 4. 1 Measurement Model of Confirmatory Factor Analysis

As illustrated in Figure 4.1, the CFA measurement framework encompassed five latent factors and their respective manifest variables. The arrows connecting each latent factor to its specific indicators depict the measurement associations between these constructs and the observable variables. The standardized factor loadings were utilized to evaluate the predictive strength of every manifest item for its associated latent construct.

Table 4. 6 Confirmatory Factor Analysis Results

Latent Variable	Item	Standardized Loading	CR	AVE
ATT	ATT1	0.761	0.894	0.584
	ATT2	0.761		
	ATT3	0.77		
	ATT4	0.764		
	ATT5	0.772		
	ATT6	0.758		
SN	SN1	0.794	0.895	0.586
	SN2	0.785		
	SN3	0.732		
	SN4	0.723		
	SN5	0.805		
	SN6	0.751		
PBC	PBC1	0.746	0.895	0.588
	PBC2	0.774		
	PBC3	0.764		
	PBC4	0.762		
	PBC5	0.778		
	PBC6	0.775		
CI	CI1	0.753	0.882	0.554
	CI2	0.756		
	CI3	0.746		
	CI4	0.76		
	CI5	0.725		
	CI6	0.725		
CRB	CRB1	0.753	0.883	0.557
	CRB2	0.736		
	CRB3	0.778		
	CRB4	0.728		
	CRB5	0.74		
	CRB6	0.743		

Based on Table 4.6, the standardized factor loadings for every observed variable varied between 0.723 and 0.805, each surpassing the frequently suggested cutoff of 0.70. This suggests that each measured item possessed a robust loading on its related latent construct and was capable of adequately representing the conceptual structure it was originally intended to evaluate.

Regarding Attitude, the standardized factor loadings varied between 0.758 and 0.772, signifying that the six ATT measures possessed consistent explanatory strength for this particular construct. Concerning Subjective Norms, the standardized factor loadings fluctuated from 0.723 to 0.805, revealing that the six SN items efficiently assessed participants' perceived social pressures and backing. For Perceived Behavioral Control, the standardized factor loadings spanned from 0.746 to 0.778, implying that the six PBC items sufficiently mirrored respondents' perceived capacity, assets, and practicality of engaging in low-carbon practices. Regarding Collective Identity, the standardized factor loadings ranged from 0.725 to 0.760, suggesting that the six CI items successfully captured subjects' communal affiliation, collective duty, and association with low-carbon activities. For Carbon Reduction Behavior, the standardized factor loadings varied from 0.728 to 0.778, illustrating that the six CRB items were suitable for evaluating real low-carbon behaviors within everyday life.

Composite reliability (CR) was further utilized to assess the internal consistency for every latent construct. The CR scores for ATT, SN, PBC, CI, and CRB were 0.894, 0.895, 0.895, 0.882, and 0.883, respectively. All CR indices surpassed the suggested minimum of 0.70, suggesting robust construct reliability. Furthermore, the AVE metrics for these five constructs were 0.584, 0.586, 0.588, 0.554, and 0.557, respectively. Given that all AVE figures exceeded the 0.50 benchmark, these findings demonstrate that each latent variable could account for more than half of the variance in its respective observed indicators.

Consequently, the findings from CFA indicate that the measurement framework exhibited adequate convergent validity. The manifest variables were robustly linked to their respective latent factors, and the five underlying constructs demonstrated high internal reliability and analytical quality.

Table 4. 7 Discriminant Validity Results

	CRB	**CI**	**PBC**	**SN**	**ATT**
CRB	0.747				
CI	0.381	0.744			
PBC	0.369	0.370	0.767		
SN	0.387	0.404	0.433	0.766	
ATT	0.394	0.408	0.457	0.407	0.764

To additionally verify discriminant validity, the square root of AVE for every construct was contrasted with the inter-latent variable correlations. The diagonal entries within Table 4.7 reflect the square roots of AVE, whereas the off-diagonal figures denote the associations between the latent variables.

As presented in Table 4.6, the square roots of AVE for the five latent constructs varied between 0.744 and 0.767. Precisely, the square root of AVE was 0.747 for carbon reduction behavior, 0.744 for collective identity, 0.767 for Perceived Behavioral Control, 0.766 for subjective norms, and 0.764 for Attitude. The correlations among these latent variables ranged from 0.369 to 0.457. The peak correlation coefficient was 0.457, which existed between Attitude and Perceived Behavioral Control. Nevertheless, this figure remained below the square roots of AVE for the respective constructs.

Given that the square root of AVE for every construct exceeded its associations with alternative constructs, the findings suggest that the five latent factors possessed adequate discriminant validity. Even though these constructs were interrelated, their correlation values remained relatively moderate. This implies that Attitude, subjective norms, Perceived Behavioral Control, collective identity, and carbon reduction behavior were theoretically linked yet statistically separate from each other.

In summary, the CFA findings verified that the measurement framework possessed excellent convergent and discriminant validity. The assessment factors were appropriate for reflecting their respective underlying constructs, and the variables were adequately distinguishable from one another. Consequently, this measurement structure offered a dependable and accurate foundation for following structural equation modeling, Bootstrap mediation testing, and hypothesis evaluation.

4.6 Structural Equation Model Analysis

Following the verification that the measurement framework exhibited adequate reliability, convergent validity, as well as discriminant validity, structural equation modeling (SEM) was utilized to investigate the proposed associations between latent constructs. The structural framework was constructed according to the conceptual foundation of this research, which incorporates the Theory of Planned Behavior alongside collective identity. More precisely, this analysis evaluated the impacts of Attitude (ATT), subjective norms (SN), and Perceived Behavioral Control (PBC) upon collective identity (CI) and carbon reduction behavior (CRB). Furthermore, the influence of collective identity on carbon reduction behavior was also explored.

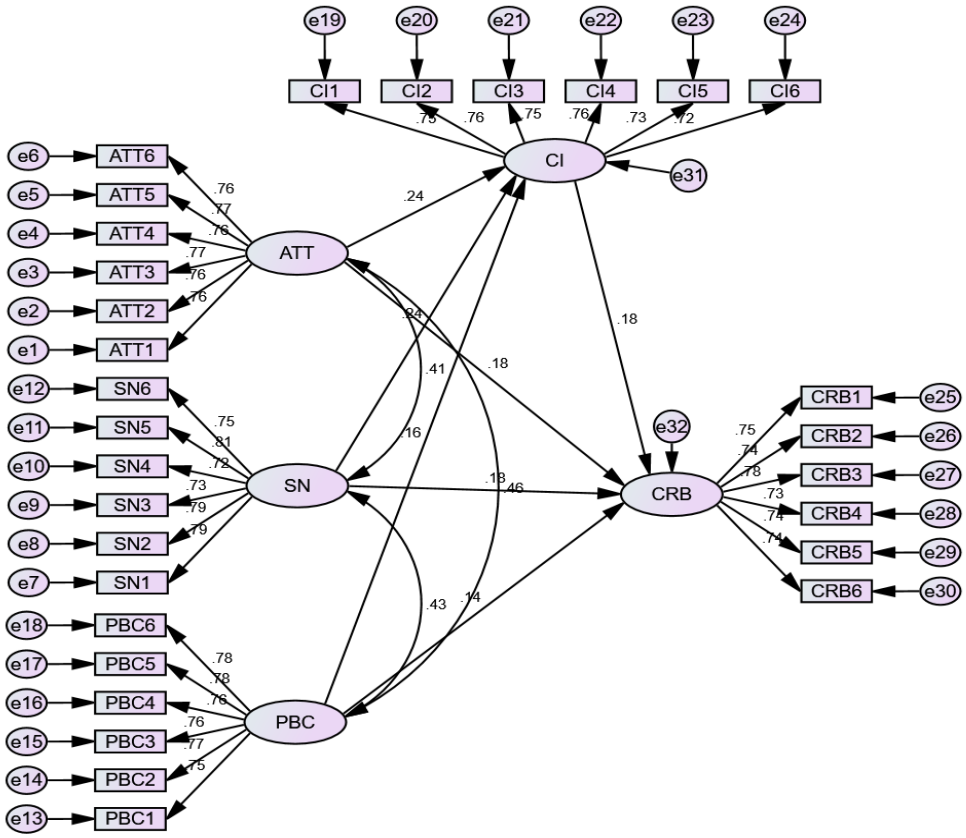

Figure 4. 2 Structural Equation Model

As illustrated in Figure 4.2, the conceptual framework encompassed both immediate and mediated pathways. These direct links comprised ATT → CRB, SN → CRB, PBC → CRB, and CI → CRB. The indirect process was represented by the connections from ATT, SN, and PBC to CI, followed by the link from CI to CRB. Consequently, this structural equation model could evaluate the straight impacts of TPB constructs on carbon mitigation actions and the function of collective identity as a mental mediator between personal perceptions and genuine low-carbon practices.

Table 4. 8 Goodness-of-Fit Test for Structural Equation Model

Fit Index	Criterion	Value
$\chi 2$	-	453.268
df	-	395
$\chi 2$/df	<3	1.148
GFI	>0.9	0.921
RMSEA	<0.10	0.021
CFI	>0.9	0.989
NFI	>0.9	0.922
RFI	>0.9	0.914
TLI	>0.9	0.988
AGFI	>0.9	0.907
IFI	>0.9	0.989

As presented in Table 4.8, the proposed structural equation model exhibited excellent general fit. The chi-square statistic was 453.268, with 395 degrees of freedom. The x^2/df ratio was 1.148, which remained below the suggested limit of 3.0, suggesting that the framework achieved high parsimony fit.

Regarding the absolute fit metrics, the GFI was 0.921 while the AGFI was 0.907, each surpassing the suggested limit of 0.90. The RMSEA was 0.021, which remained below the frequently adopted benchmark of 0.08. This suggests that the disparity between the proposed framework and the empirical evidence was minimal.

Regarding the additional fit measures, the CFI, NFI, RFI, TLI, and IFI scores were 0.989, 0.922, 0.914, 0.988, and 0.989, respectively. Each of these figures surpassed the established threshold of 0.90, implying that the conceptual structural framework aligned

well with the empirical dataset relative to the reference model. Collectively, the fit statistics demonstrate that the SEM achieved a reasonable and adequate alignment, thereby making it suitable for subsequent path exploration and hypothesis evaluation.

Table 4. 9 Coefficient of Determination (R^2) of Endogenous Constructs

Endogenous Construct	R^2	Explained Variance
Collective Identity (CI)	0.252	25.2%
Carbon Reduction Behavior (CRB)	0.262	26.2%

Beyond evaluating the importance of structural pathways, the predictive strength of this conceptual framework was measured through the coefficient of determination (R^2). R^2 represents the degree of variability within an internal construct which can be accounted for jointly by its independent variables (Hair et al., 2019).

This research incorporated two internal constructs within the theoretical framework: collective identity (CI) and carbon reduction behavior (CRB). According to Table 4.9, the R^2 value for collective identity reached 0.252, suggesting that behavioral attitude, subjective norm, and perceived behavioral control collectively accounted for 25.2% of the fluctuations in collective identity.

Additionally, the R^2 figure for carbon mitigation conduct reached 0.262, indicating that behavioral mindset, subjective pressure, perceived behavioral power, and collective consciousness jointly accounted for 26.2% of the fluctuations in carbon mitigation actions.

These findings demonstrate that the suggested unified framework merging the Theory of Planned Behavior with collective identity offers significant interpretive strength in elucidating the development process of carbon mitigation actions among Thai university students.

Table 4. 10 Path Coefficients of the Structural Equation Model

Path			Unstandardized Coefficient	S.E.	C.R.	P	Standardized Coefficient
CI	<---	ATT	0.234	0.065	3.595	***	0.239
CI	<---	SN	0.218	0.060	3.641	***	0.238
CI	<---	PBC	0.160	0.067	2.372	0.018	0.158
CRB	<---	CI	0.181	0.064	2.807	0.005	0.183
CRB	<---	ATT	0.176	0.065	2.706	0.007	0.182
CRB	<---	SN	0.161	0.060	2.690	0.007	0.178
CRB	<---	PBC	0.141	0.067	2.106	0.035	0.140

The findings regarding path coefficients are presented in Table 4.10. Initially, Attitude exerted a substantial positive influence on collective identity, exhibiting an unstandardized coefficient of 0.234, a t-value of 3.595, and a standardized coefficient of 0.239. The p-value was less than 0.001, demonstrating that this relationship was statistically significant. This outcome implies that learners who held more favorable judgments of low-carbon actions tended to cultivate a more robust sense of collective identity concerning carbon mitigation.

Furthermore, subjective norms exerted a substantial positive influence on collective identity, displaying an unstandardized coefficient of 0.218, a t-statistic of 3.641, and a standardized coefficient of 0.238. The p-value fell below 0.001. This suggests that external pressures and support from peers, acquaintances, instructors, college personnel, and kinfolk might bolster students' shared sense of belonging regarding low-carbon activities.

Furthermore, Perceived Behavioral Control exerted a substantial positive influence on collective identity, exhibiting an unstandardized coefficient of 0.160, a critical ratio of 2.372, a p-value of 0.018, and a standardized coefficient of 0.158. This finding indicates that whenever learners viewed low-carbon practices as achievable and under their personal authority, they tended to incorporate such eco-friendly conduct into their collective self-image and communal accountability.

Furthermore, collective identity exerted a substantial positive influence on carbon mitigation actions, featuring an unstandardized coefficient of 0.181, a t-value of 2.807, a p-value of 0.005, and a standardized coefficient of 0.183. This result suggests that pupils possessing a more robust collective identity tended to be more inclined to perform genuine carbon reduction activities. In short, when sustainable conduct was regarded as a component of a mutual student character and communal obligation, learners were more prone to convert this identity into tangible low-carbon initiatives.

Beyond the impact of shared identity, the three TPB components also possessed substantial direct influences on carbon mitigation activities. Attitude exerted a meaningful positive influence on carbon reduction conduct, featuring an unstandardized coefficient of 0.176, a critical ratio of 2.706, a p-value of 0.007, and a standardized coefficient of 0.182. This finding suggests that pupils who maintained more favorable opinions about low-carbon practices were more inclined to perform carbon reduction tasks within their everyday lives.

Perceived subjective norms also exerted a substantial positive impact on carbon mitigation actions, featuring an unstandardized coefficient of 0.161, a t-value of 2.690, a p-value of 0.007, and a standardized coefficient of 0.178. This indicates that anticipated societal pressures and backing might directly motivate learners to engage in low-carbon practices.

Perceived Behavioral Control exerted a substantial positive influence on carbon mitigation actions, featuring an unstandardized parameter of 0.141, a t-value of 2.106, a p-value of 0.035, and a standardized coefficient of 0.140. This finding suggests that learners who felt they possessed adequate skills, assets, and chances to execute low-carbon activities tended to participate more actively in real carbon reduction tasks.

In summary, the structural equation modeling outcomes indicate that Attitude, subjective norms, Perceived Behavioral Control, and collective identity each exerted substantial positive influences on carbon reduction actions. Regarding direct determinants of carbon reduction conduct, collective identity exhibited the most robust standardized impact, followed by Attitude, subjective norms, and Perceived Behavioral Control. Such evidence implies that university students in Thailand’s carbon reduction practices are influenced not merely by personal cognitive elements but additionally by the internalization of collective identity.

4.7 Bootstrap Mediation Effect Test

Following the assessment of direct correlations between these variables via structural equation modeling, the Bootstrap technique was additionally employed to investigate the mediating function of collective identity. Within this research, collective identity was conceptualized as a mediating factor connecting the three TPB dimensions with carbon reduction actions. Precisely, this portion evaluates whether Attitude, subjective norms, and Perceived Behavioral Control exert indirect impacts on carbon reduction behavior via the channel of collective identity.

The Bootstrap procedure is appropriate for evaluating mediation impacts since it lacks dependence on the presumption of normality regarding indirect influences. Within this research, the mediation impact was deemed statistically meaningful if the 95% confidence interval excluded zero. The outcomes of the Bootstrap mediation examination are displayed in Table 4.11.

Table 4. 11 Bootstrap Mediation Effect Test Results

Parameter	Estimate	Lower	Upper	P	Result
Indirect Effect:ATT→CI→CRB	0.044	0.013	0.096	0.002	Supported
Direct Effect: ATT→CRB	0.182	0.046	0.315	0.019	Supported
Total Effect: ATT→CRB	0.226	0.099	0.350	0.001	Supported
Indirect Effect:SN→CI→CRB	0.043	0.014	0.091	0.002	Supported
Direct Effect: SN→CRB	0.178	0.056	0.309	0.006	Supported
Total Effect: SN→CRB	0.221	0.098	0.350	0.001	Supported
Indirect Effect:PBC→CI→CRB	0.029	0.005	0.073	0.016	Supported
Direct Effect: PBC→CRB	0.140	-0.003	0.271	0.057	Not Supported
Total Effect: PBC→CRB	0.169	0.019	0.298	0.020	Supported

According to Table 4.11, the indirect impact of Attitude on carbon reduction practices via collective identity amounted to 0.044. The 95% confidence interval spanned 0.013 to 0.096, failing to encompass zero, with a p-value of 0.002. Consequently, the mediating role of collective identity connecting Attitude and carbon reduction behavior proved statistically meaningful. Furthermore, the direct influence of Attitude on carbon reduction actions was 0.182, featuring a 95% confidence interval between 0.046 and 0.315

plus a p-value of 0.019. As both direct and indirect impacts were significant, collective identity partially bridged the correlation between Attitude and carbon reduction behavior.

The indirect influence of subjective norms on carbon mitigation actions via collective identity amounted to 0.043. The 95% confidence interval spanned between 0.014 and 0.091, excluding zero, with a p-value of 0.002. This suggests that collective identity substantially mediated the connection between subjective norms and carbon mitigation behavior. Concurrently, the direct impact of subjective norms on carbon mitigation behavior was 0.178, possessing a 95% confidence interval of 0.056 to 0.309 and a p-value of 0.006. Consequently, collective identity likewise performed a partial mediating function between subjective norms and carbon mitigation behavior.

The mediated influence of Perceived Behavioral Control on carbon reduction actions via collective identity was 0.029. The 95% confidence interval spanned from 0.005 to 0.073, excluding zero, with a p-value of 0.016. This finding indicates that the mediating role of collective identity between Perceived Behavioral Control and carbon reduction behavior was statistically substantial. Nevertheless, the direct impact of Perceived Behavioral Control on carbon reduction behavior amounted to 0.140, featuring a 95% confidence interval between -0.003 and 0.271 and a p-value of 0.057. As the confidence interval contained zero and the p-value exceeded 0.05, the direct influence was not statistically significant within the Bootstrap mediation analysis. Consequently, Perceived Behavioral Control primarily affected carbon reduction behavior indirectly through collective identity.

In summary, the Bootstrap mediation analysis demonstrates that collective identity plays a substantial role in mediating the impacts of Attitude, subjective norms, and Perceived Behavioral Control regarding carbon reduction actions. Across these three indirect pathways, the mediating strength of Attitude was most prominent, followed by subjective norms and Perceived Behavioral Control. Such results imply that collective identity functions as a vital psychological framework through which personal attitudes, perceived social pressures, and perceived behavioral facilitation are translated into real carbon reduction activities. Consequently, hypotheses H3a, H3b, and H3c received empirical validation.

4.8 Summary of Hypothesis Testing Results

This portion encapsulates the empirical findings regarding the structural equation model alongside Bootstrap mediation evaluations. Initially, Table 4.12 displays the quantitative outcomes for every hypothesis, encompassing both direct impacts and mediated pathways. Subsequently, Table 4.12 additionally contrasts the current discoveries against prior empirical and conceptual literature. The objective of this juxtaposition is to investigate whether the orientation and statistical importance of the correlations discovered herein align with previous investigations into pro-environmental conduct, carbon mitigation actions, the Theory of Planned Behavior, and social identity frameworks.

Table 4. 12 Summary of Hypothesis Testing Results

Hypothesis	Path	Standardized Coefficient / Indirect Effect	p-value	Result
H1a	ATT → CRB	0.182	0.007	Supported
H1b	SN → CRB	0.178	0.007	Supported
H1c	PBC → CRB	0.140	0.035	Qualified Support
H2	CI → CRB	0.183	0.005	Supported
H3a	ATT → CI → CRB	0.044	0.002	Supported
H3b	SN → CI → CRB	0.043	0.002	Supported
H3c	PBC → CI → CRB	0.029	0.016	Supported

As displayed in Table 4.12, every proposed hypothesis received validation from the empirical findings. Precisely, Attitude exerted a substantial positive impact on carbon reduction actions ($\beta = 0.182$, $p = 0.007$), corroborating H1a. Subjective norms likewise demonstrated a meaningful positive influence on carbon reduction practices ($\beta = 0.178$, $p = 0.007$), validating H1b. Perceived Behavioral Control exhibited a meaningful positive influence on carbon reduction behavior within the structural equation model ($\beta = 0.140$, $p = 0.035$). Nevertheless, the Bootstrap mediation analysis suggested that the direct influence was not statistically significant (95% CI [-0.003, 0.271], $p = 0.057$). Consequently, H1c garnered conditional support, implying that perceived behavioral

control might affect carbon reduction behavior primarily via collective identity. Furthermore, collective identity exhibited a significant positive influence on carbon reduction behavior ($\beta = 0.183$, $p = 0.005$), confirming H2.

The findings from the Bootstrap mediation analysis demonstrated that collective identity substantially acted as a mediator in the connections among the three TPB components and carbon-reducing actions. The mediated effect of Attitude on carbon reduction via collective identity amounted to 0.044, possessing a p-value of 0.002, validating H3a. Furthermore, the mediated impact of subjective norms on carbon reduction through collective identity reached 0.043, with a p-value of 0.002, confirming H3b. Additionally, the mediated influence of Perceived Behavioral Control on carbon reduction via collective identity was 0.029, featuring a p-value of 0.016, corroborating H3c.

To summarize, these findings suggest that carbon mitigation activities among college students are shaped by both personal psychological elements, such as attitude, subjective norms, and perceived behavioral control, and by shared identity. This observation validates the combined conceptual structure of the Theory of Planned Behavior and Social Identity Theory utilized within this research.

Table 4. 13 Summary and Comparison of Hypothesis Testing Results

Hypothesis	Path	Present result	Previous-study comparison	Conclusion
H1a	ATT → CRB	$\beta = 0.182$, $p = 0.007$	Consistent with de Leeuw et al. (2015) and Blok et al. (2015), who supported the role of favorable environmental evaluations in pro-environmental behavior	Supported
H1b	SN → CRB	$\beta = 0.178$, $p = 0.007$	Consistent with Helferich et al. (2023), who found that injunctive and descriptive norms predicted pro-environmental behavior	Supported

Table 4. 13 (Continued)

Hypothesis	Path	Present result	Previous-study comparison	Conclusion
H1c	PBC → CRB	SEM: β = 0.140, p = 0.035; Bootstrap CI [−0.003, 0.271], p = 0.057	Direction consistent with TPB studies, but the direct effect was not robust in the Bootstrap test	Qualified support
H2	CI → CRB	β = 0.183, p = 0.005	Consistent with Fielding and Hornsey (2016), Fritsche et al. (2018), and Wang et al. (2021)	Supported
H3a	ATT → CI → CRB	Indirect effect = 0.044, CI [0.013, 0.096], p = 0.002	Consistent with Wang et al.'s (2021) identity-mediated environmental value–behavior pathway	Supported; partial mediation
H3b	SN → CI → CRB	Indirect effect = 0.043, CI [0.014, 0.091], p = 0.002	Consistent with norm-internalization evidence and SIMPEA's identity–group norm mechanism	Supported; partial mediation
H3c	PBC → CI → CRB	Indirect effect = 0.029, CI [0.005, 0.073], p = 0.016	Broadly consistent with SIMPEA's efficacy–identity mechanism; exact pathway remains under-researched	Supported; indirect-only mediation

Table 4.13 contrasts the current study's hypothesis test outcomes with prior empirical and conceptual research. This comparison indicates that the majority of these findings align generally with earlier investigations into pro-environmental actions, the Theory of Planned Behavior, and social identity processes.

Initially, the substantial positive influence of Attitude on carbon reduction conduct aligns with de Leeuw et al. (2015), who discovered that the Theory of Planned Behavior aided in clarifying adolescents' pro-environmental actions. It additionally corresponds with Blok et al. (2015), who demonstrated that TPB-related mental variables played a role in elucidating pro-environmental conduct within an academic workplace context. This implies that learners who possess positive perceptions regarding carbon reduction are more likely to participate in real low-carbon practices.

Furthermore, the substantial positive impact of subjective norms on carbon reduction actions aligns with Helferich et al. (2023), who discovered that both injunctive and descriptive norms were key predictors of pro-environmental conduct. Within the framework of this research, university pupils might be shaped by peers, instructors, relatives, campus groups, and institutional aspirations. Consequently, perceived social pressures and backing can motivate students to engage in carbon reduction initiatives.

Furthermore, Perceived Behavioral Control exhibited a substantial positive impact on carbon reduction actions within the structural equation framework. This finding broadly aligns with the Theory of Planned Behavior, which highlights the importance of perceived behavioral control in influencing conduct (Ajzen, 1991). Nevertheless, the Bootstrap direct effect remained insignificant as the confidence interval encompassed zero and the p-value exceeded 0.05. Consequently, H1c must be regarded as receiving conditional validation. This suggests that perceived behavioral control might affect carbon reduction behavior more powerfully via collective identity rather than through a steady isolated direct route.

Furthermore, group-based identity exerted a substantial beneficial influence on carbon-cutting activities. This result aligns with Fielding and Hornsey (2016), who maintained that social self-concept could mold ecological perspectives and conduct. It furthermore matches the Social Identity Model of Pro-Environmental Action developed by Fritsche et al. (2018), which clarifies green behavior via collective affiliation, communal standards, and shared confidence. Additionally, Wang et al. (2021) discovered that ecological collective identity was connected to pro-nature conduct in academic populations. Such research corroborates the observation that learners are more inclined to execute carbon mitigation actions when they perceive such efforts as components of common societal principles and communal obligation.

Ultimately, the Bootstrap analysis revealed that collective identity substantially mediated the associations among Attitude, subjective norms, Perceived Behavioral Control, and carbon reduction actions. The mediation impacts of H3a and H3b demonstrate that favorable ecological assessments and perceived societal pressures can be translated into real low-carbon conduct through identity internalization. The mediation impact of H3c additionally implies that perceived behavioral feasibility might become more psychologically potent when it is linked with a collective student identity. Consequently, this research broadens prior scholarship by illustrating that collective identity serves as a

vital psychological link between personal cognition, social pressure, perceived control, and actual carbon reduction practices.



CHAPTER 5
DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section analyzes and clarifies the empirical results displayed within Chapter 4. The main objective of this chapter is to elucidate the connections between behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction actions among university students residing in Thailand.

This research established a unified conceptual model merging the Theory of Planned Behavior (TPB) with Social Identity Theory to offer a more thorough comprehension of how personal psychological variables and collective identity dynamics affect carbon mitigation actions. Although TPB focuses on the impact of personal cognition, encompassing behavioral attitudes, perceived social norms, and perceived control, Social Identity Theory underscores the significance of group affiliation, common values, and identity-driven incentives in molding individual conduct (Ajzen, 1991; Tajfel & Turner, 1979).

Diverging from research which solely analyzes ecological conduct via a private choice viewpoint, this inquiry additionally explores how private environmental awareness and societal pressures are translated into concrete action patterns through shared group identity. Consequently, the analysis emphasizes not merely if the suggested factors substantially affect carbon mitigation habits but also why such connections emerge within the framework of tertiary education in Thailand.

Subsequent sections analyze the primary results of this investigation by contrasting them with prior conceptual and observational studies. Following that, the conceptual merits, functional ramifications, study constraints, and prospective research avenues are discussed. Via this analysis, this segment emphasizes how the amalgamation of TPB and communal identity enhances a more profound comprehension of carbon mitigation actions within college pupils.

5.2 Discussion of Research Findings

This segment explores the empirical evidence by merging the outcomes of this research with current conceptual frameworks and prior studies on ecological conduct. Instead of merely reiterating the quantitative findings, this analysis emphasizes clarifying the processes by which personal perception, societal pressure, and communal belonging collectively promote carbon emission mitigation activities.

Based on the integrated TPB–collective identity framework, this study examined the effects of behavioral attitude, subjective norm, and perceived behavioral control on carbon reduction behavior, the influence of collective identity, and the mediating role of collective identity in transforming psychological factors into actual behavioral actions.

The findings demonstrate that carbon reduction behavior is shaped by both individual cognitive processes and identity-based psychological mechanisms. While TPB provides an important explanation of how personal evaluations, social expectations, and perceived capability influence behavior, the inclusion of collective identity reveals how environmental values become internalized and translated into sustainable actions. This finding suggests that carbon reduction behavior, particularly within a collectivist cultural context, cannot be fully explained through individual decision-making processes alone.

5.2.1 The Effects of TPB Factors on Carbon Reduction Behavior

The outcomes of this research validate that the three TPB components—behavioral attitude, subjective norm, and perceived behavioral control—are significantly linked to carbon reduction actions. Such conclusions offer empirical evidence for Ajzen's (1991) Theory of Planned Behavior and align with earlier ecological behavior studies suggesting that personal cognition, perceived social pressures, and behavioral capacity are crucial drivers of pro-environmental conduct (Bamberg & Möser, 2007; Steg & Vlek, 2009).

Initially, behavioral attitude exhibited a substantial positive influence on carbon reduction activities. This discovery suggests that learners who view low-carbon measures as significant, advantageous, and ecological accountable are more inclined to participate in carbon reduction efforts. This outcome aligns with prior research implying that favorable environmental perspectives constitute a vital incentive base for sustainable conduct (Steg & Vlek, 2009).

However, the influence of attitude alone may not fully explain behavioral implementation. Students may recognize the importance of carbon reduction but still experience difficulties maintaining consistent behaviors due to social environments, limited opportunities, or insufficient behavioral reinforcement. Therefore, the findings suggest that although environmental attitudes provide an important psychological foundation, additional mechanisms are required to transform personal values into continuous behavioral practices.

Furthermore, subjective norm exhibited a substantial positive influence on carbon mitigation activities. This result emphasizes the vital role of societal pressure in molding students' ecological initiatives. Prior studies have shown that people are more inclined to practice green behaviors if they feel demands and backing from key figures, such as relatives, friends, and organizations (Ajzen, 1991; Bamberg & Möser, 2007).

In the context of Thai higher education, subjective norm may play an important role because social relationships, interpersonal harmony, and group expectations influence individual decision-making. Thailand has been widely discussed as a society with strong interpersonal orientation and collectivist characteristics, where individuals often consider the expectations and values of their social groups when making behavioral decisions (Hofstede, 2001). Therefore, students may participate in carbon reduction behaviors not only because they personally value environmental protection but also because such behaviors are supported and encouraged within their university communities.

Third, perceived behavioral control showed a positive relationship with carbon reduction behavior in the structural model. This finding supports Ajzen's (1991) argument that individuals are more likely to perform a behavior when they believe they possess sufficient resources, ability, and opportunities.

However, the Bootstrap mediation analysis showed that the direct effect of perceived behavioral control on carbon reduction behavior became marginally insignificant after considering the mediating role of collective identity. Therefore, H1c received qualified support, indicating that perceived behavioral control contributes to carbon reduction behavior, but its direct influence may become weaker when identity-based motivation is considered.

This discovery offers a significant expansion to the conventional TPB framework. While perceived behavioral control indicates pupils' self-assurance regarding executing low-carbon activities, mere perceived capacity might not necessarily result in real conduct. Within collectivist schooling settings, learners are more inclined to convert proficiency into practice when carbon mitigation is viewed as a collective obligation instead of simply a personal selection.

5.2.2 The Role of Collective Identity in Carbon Reduction Behavior

The findings of this study demonstrate that collective identity has a significant positive effect on carbon reduction behavior among university students studying in Thailand. Among the direct predictors examined in the structural model, collective identity showed the strongest influence on carbon reduction behavior ($\beta = 0.183$), slightly exceeding behavioral attitude ($\beta = 0.182$). This finding indicates that students' low-carbon actions are not determined only by their personal evaluation of environmental behaviors but are also strongly influenced by their identification with groups that share environmental values and responsibilities.

This result supports the perspective of Social Identity Theory, which proposes that individuals define themselves partly through their membership in social groups and tend to behave consistently with the norms, values, and expectations associated with those groups (Tajfel & Turner, 1979). When environmental protection becomes incorporated into an individual's collective identity, carbon reduction behavior is no longer viewed merely as a personal choice but becomes an expression of belonging, responsibility, and commitment toward a meaningful social group.

An important finding of this study is that collective identity demonstrated a slightly stronger effect than behavioral attitude. Previous environmental behavior research, particularly studies conducted in Western individualistic contexts, has often emphasized personal attitudes, individual values, and personal responsibility as the primary motivations for environmental action (Bamberg & Möser, 2007; Steg & Vlek, 2009). In such contexts, individuals may engage in carbon reduction behavior mainly because they personally believe that environmental protection is valuable and beneficial.

However, the current finding provides a different perspective by demonstrating that group-based psychological mechanisms may become equally or even more influential in collectivist cultural environments. Thailand has traditionally been characterized by collectivist cultural tendencies, where interpersonal relationships, social harmony, and group belonging play important roles in individual decision-making processes (Hofstede, 2001). Within such a context, university students may perceive carbon reduction behavior not only as an individual environmental responsibility but also as a reflection of their identity as members of a university community.

This finding is consistent with previous research emphasizing the importance of social identity in environmental action. Fielding and Hornsey (2016) argued that environmental behaviors are more likely to occur when individuals perceive environmental protection as part of a meaningful social identity. Similarly, Fritsche et al. (2018) proposed the Social Identity Model of Pro-Environmental Action (SIMPEA), suggesting that group identification can transform individual environmental concerns into collective action by creating shared goals, social responsibility, and behavioral commitment.

The present study extends previous environmental behavior research by demonstrating that collective identity provides additional explanatory value beyond traditional TPB variables. While TPB explains how individual cognition influences behavioral decisions, it provides relatively limited explanation regarding how social values become internalized and maintained as part of personal motivation. By integrating collective identity into the TPB framework, this study demonstrates that carbon reduction behavior is developed through both rational evaluation and identity-based motivation.

Furthermore, this finding has important implications for understanding carbon reduction behavior within multicultural higher education environments. Since this study included both Thai domestic students and Chinese international students studying in Thailand, the results suggest that collective identity may function as an important psychological mechanism within diverse student populations. This highlights that universities should not only promote environmental knowledge but also cultivate shared environmental identities among students.

5.2.3 The Mediating Role of Collective Identity in the Formation of Carbon Reduction Behavior

This mediation framework offers deeper understanding regarding how personal mental states are translated into genuine greenhouse gas emission mitigation actions. The data show that communal identity notably acts as a mediator for the connections between action-oriented attitudes, personal norms, perceived control, and carbon-cutting practices. Such outcomes imply that learners' ecological conduct is not merely straightforward consequences of private convictions or societal pressures but is molded via the mechanism of identity integration.

Initially, group-based identity serves as a mediator between behavioral stance and carbon mitigation actions. This conclusion implies that favorable ecological perspectives become more powerful when learners view sustainable habits as aligning with the principles of the communities they identify with. Even if pupils acknowledge the significance of ecological preservation, individual consciousness might not frequently lead to persistent practical involvement. Via the development of collective identity, private ecological views can be converted into collective pledges, enhancing the alignment between ecological convictions and real-world conduct.

This discovery broadens the conventional understanding of TPB. Per Ajzen (1991), positive attitudes boost behavioral propensity since people assess the action as attractive and advantageous. Nonetheless, the current research indicates that within a collectivist societal setting, the link between attitude and behavior might also rely on whether ecological values are incorporated into persons' communal identities. When learners view carbon mitigation as a component of "who they are" as participants of a collective, behavioral drive becomes more robust and enduring.

Furthermore, collective identity serves as a mediator for the link between subjective norm and carbon reduction action. This discovery elucidates the conceptual difference between subjective norm and collective identity. Subjective norm reflects the perceived external demands and social pressure exerted by significant individuals, while collective identity denotes the internal psychological sense of belonging to a community and its common principles.

The mediating mechanism illustrates a progression of conversion from outside pressure to inner drive. Learners might begin participating in carbon-cutting activities due to aspirations from classmates, institutions, or community organizations. Nevertheless, as such aspirations are assimilated into their collective self-image, carbon mitigation practices turn into an autonomous act grounded in collective accountability instead of exterior compulsion.

This discovery aligns with Social Identity Theory and prior ecological identity studies, which propose that communal affiliation may inspire people to behave in accordance with shared ideals (Tajfel & Turner, 1979; Fritsche et al., 2018). Consequently, collective identity offers a vital framework for elucidating how societal standards are assimilated and converted into enduring ecological practices.

Third, shared identity serves as a mediator in the link between perceived behavioral control and carbon-cutting actions. This discovery offers a rationale for why perceived behavioral control exhibited a less robust direct impact once the mediating process was taken into account. Even if pupils might feel they possess adequate skills, assets, and chances to execute carbon-cutting activities, such beliefs might not necessarily result in concrete performance.

The findings suggest that subjective perceived behavioral control might necessitate identity-oriented inspiration to function efficiently. Specifically, learners are more inclined to utilize their skills and accessible assets for carbon mitigation when they view these actions as significant manifestations of their collective affiliation and mutual duty. This discovery broadens prior TPB studies by illustrating that practical capability alone could be inadequate unless accompanied by a psychological connection to ecological principles.

In summary, the mediation results illustrate that collective identity serves as a mental link spanning personal perception, societal impact, and action execution. Consequently, merging TPB with Social Identity Theory offers a more holistic interpretation of carbon mitigation actions by uncovering not just if learners are ready and capable of undertaking low-carbon activities but also how such incentives are converted into tangible practices.

By adopting this holistic viewpoint, the research advances environmental conduct studies by demonstrating that carbon mitigation actions are not simply outcomes of personal choices but rather a procedure of communal identity construction and normative integration.

5.3 Theoretical Contributions

This research enhances environmental behavior scholarship by merging the Theory of Planned Behavior (TPB) with Social Identity Theory to construct a more holistic framework for elucidating carbon mitigation actions among Thai university students. Former investigations have widely utilized TPB to clarify pro-environmental activities; nevertheless, numerous works have primarily concentrated on personal cognitive elements and offered minimal insights into how social impacts are integrated and converted into consistent practical habits.

By integrating collective identity as a mediating variable, this research broadens current theoretical frameworks by clarifying not merely the determinants of carbon mitigation practices but also the cognitive pathways via which such variables are transformed into tangible ecological activities.

5.3.1 Extension of the Theory of Planned Behavior through Collective Identity

The primary theoretical advancement of this research involves expanding the Theory of Planned Behavior by incorporating collective identity into the mechanism of behavior development. TPB suggests that behavioral attitude, subjective norm, and perceived behavioral control are key factors influencing behavioral intention and real action (Ajzen, 1991). Former environmental conduct investigations have shown the validity of TPB in clarifying sustainable activities, encompassing recycling, energy saving, and various pro-environmental practices (Bamberg & Möser, 2007; Steg & Vlek, 2009).

Nevertheless, conventional TPB mainly focuses on cognitive mechanisms at the individual level. While subjective norm reflects social pressure, it primarily embodies people's views of external pressures instead of their deep internal emotional ties to a collective. Consequently, TPB by itself might not adequately clarify how ecological beliefs become socially integrated and preserved as components of personal identities.

To tackle this constraint, this research incorporates collective identity as an extra mediating pathway. The results show that collective identity substantially impacts carbon mitigation conduct and offers supplementary theoretical clarification beyond conventional TPB variables. The structural framework revealed that collective identity exerted a considerable positive influence on carbon reduction practices, and the combined model accounted for 26.2% of the fluctuation in carbon reduction actions ($R^2 = 0.262$). This suggests that integrating identity-driven psychological processes offers valuable interpretive understanding regarding students' low-carbon behaviors.

Moreover, shared identity accounted for 25.2% of the explained variance ($R^2 = 0.252$), indicating that TPB-derived cognitive elements impact the development of students' ecological group identity. Consequently, this research expands TPB by illustrating that carbon mitigation actions are driven not merely by logical assessment and perceived competence but also by the degree to which participants internalize ecological values as components of their collective identity.

5.3.2 Clarifying the Psychological Mechanism Linking Cognition and Behavior

A secondary scholarly contribution from this research involves the discovery of the mental process whereby ecological awareness is translated into tangible actions. Earlier investigations have validated that opinions, societal expectations, and perceived capability impact green practices; nonetheless, the pathway linking such mental variables to the execution of actions is still inadequately examined.

This research illustrates that shared identity functions as a mental link connecting TPB elements with carbon mitigation actions. The mediation outcomes suggest that collective identity substantially bridges the connections between behavioral attitude, subjective norm, perceived behavioral control, and carbon reduction conduct. These results demonstrate that personal convictions and societal pressures do not always prompt behavior directly but might occur via the internalization of identity.

Specifically, this research elucidates the theoretical difference between subjective norm and collective identity. Subjective norm signifies perceived anticipations or societal influence from significant individuals, whereas collective identity denotes a person's internal affiliation with a community and endorsement of common principles. Such differentiation illustrates the evolutionary shift from peripheral social pressure to internalized conduct inspiration.

The observation concerning perceived behavioral control adds significant value to conceptual insights. While perceived behavioral control represents people's self-assurance and capacity to execute carbon mitigation actions, the evidence implies that competence alone might not consistently be adequate. When collective identity is taken into account, the straightforward impact of perceived behavioral control turns less powerful, suggesting that functional capability could necessitate identity-driven inspiration to be transformed into real behavior.

Consequently, this research enhances environmental psychology scholarship by demonstrating that eco-friendly conduct development entails more than intellectual assessment; it also involves a mechanism of social identity integration.

5.3.3 Providing Empirical Evidence from the Thai Higher Education Context

Another significant theoretical advance of this research is offering empirical insights within the framework of Thai tertiary educational settings. Former studies on ecological conduct have been performed primarily in Western environments, wherein personal perspectives, private ethics, and private accountability are frequently highlighted as primary driving forces.

Through investigating students enrolled in Thailand, this research offers evidence demonstrating that collective identity serves as a crucial framework for interpreting carbon mitigation practices within a collectivist societal setting. The results indicate that learners' ecological behaviors are shaped not merely by individual ecological convictions but also by their feeling of affiliation with communities that possess conservation values and duties.

The socio-cultural landscape of Thailand offers a profound backdrop for investigating identity-driven ecological conduct. Within communities where social connections and communal membership hold great weight, people might be more inclined to practice actions aligning with the norms and aspirations of their collective circles (Hofstede, 2001). Consequently, the prominent influence of shared identity highlighted in this research offers further proof that sustainability action frameworks must incorporate cultural and societal identity elements.

Furthermore, the auxiliary nationality contrast evaluation involving Thai local learners and Chinese overseas students offers extra situational perspective. While variations were noticed in genuine carbon mitigation actions, no substantial disparities were identified in primary psychological frameworks, encompassing behavioral stance,

subjective norm, perceived behavioral control, and collective identity. This implies that the suggested cognitive process could function among various university cohorts within the Thai tertiary education settings.

In summary, this research enhances existing scholarship by illustrating that carbon mitigation actions emerge from the synergy among personal cognition, societal impact, and shared identity. The combined TPB–collective identity model offers a more extensive conceptual viewpoint for interpreting eco-friendly conduct, especially regarding college students within culturally heterogeneous academic environments.

5.4 Practical Recommendations

Based on the findings of this study, several practical recommendations are proposed for universities, student organizations, and environmental policymakers to promote carbon reduction behavior among university students studying in Thailand. Unlike traditional approaches that mainly focus on increasing environmental awareness or providing general environmental information, the findings of this study demonstrate that carbon reduction behavior is strongly influenced by collective identity and its mediating role between individual cognition and behavioral outcomes.

Therefore, effective interventions should not only focus on improving students' environmental knowledge and personal motivation but also emphasize the development of shared environmental identities, supportive social environments, and practical conditions that enable students to perform low-carbon actions. The following recommendations are developed based on the empirical findings of this study.

5.4.1 Developing a Low-Carbon Student Identity

The findings of this study indicate that collective identity plays a critical role in promoting carbon reduction behavior. Collective identity showed the strongest direct influence among the predictors, suggesting that students are more likely to engage in low-carbon actions when they perceive environmental responsibility as part of their group membership and shared values.

Therefore, universities should develop a clear "Low-Carbon Student Identity" to encourage students to view sustainable behavior as an important component of being a responsible university member. Rather than presenting carbon reduction as an individual

obligation, universities should emphasize that environmental protection represents a collective commitment shared by the entire student community.

Practical strategies may include establishing low-carbon student certification programs, creating sustainability achievement records, issuing green student badges, and recognizing students who consistently participate in carbon reduction activities. Universities may also introduce awards such as “Low-Carbon Student,” “Green Student Ambassador,” or “Campus Sustainability Pioneer” to strengthen students’ emotional connection with environmental values.

Through these identity-based approaches, students may gradually internalize carbon reduction behavior as part of their self-concept and group belonging. This approach directly reflects the finding that collective identity functions as an important mechanism through which environmental cognition is transformed into actual behavior.

5.4.2 Strengthening Peer-Based Low-Carbon Social Norms

The results of this study demonstrate that subjective norm significantly influences carbon reduction behavior and also contributes to behavioral formation through collective identity. This finding suggests that universities should utilize peer influence and group-based social environments to encourage sustainable practices.

Instead of relying only on individual environmental campaigns, universities can create collective activities that allow students to experience carbon reduction as a shared group goal. For example, universities may organize faculty-level low-carbon challenges, dormitory energy-saving competitions, green campus campaigns, and student organization sustainability projects.

For example, different faculties or student groups could participate in competitions based on measurable indicators, such as reducing electricity consumption, decreasing single-use plastic use, increasing recycling participation, or promoting sustainable transportation. Public recognition of successful groups can further strengthen positive social norms and encourage students to perceive low-carbon behavior as a common expectation within their university community.

These group-oriented interventions are particularly important because the findings indicate that social influence becomes more effective when it is internalized as collective identity rather than remaining only as external pressure. Therefore, universities should transform environmental expectations into shared group values.

5.4.3 Enhancing Behavioral Control through Supportive Campus Conditions

The findings indicate that perceived behavioral control has a positive relationship with carbon reduction behavior; however, its direct effect became less robust when the mediating role of collective identity was considered. This suggests that providing students with behavioral opportunities and resources is necessary but may not be sufficient to ensure consistent low-carbon actions.

Therefore, universities should improve students' practical ability to engage in carbon reduction behaviors while simultaneously strengthening their environmental identity. Specific measures may include expanding recycling facilities, improving waste-sorting systems, providing bicycle-sharing or sustainable transportation options, installing energy-saving equipment in dormitories, and increasing access to environmentally friendly consumption choices.

These practical conditions can reduce external barriers and increase students' perceived ability to perform carbon reduction behaviors. However, based on the findings of this study, such facilities should be implemented together with identity-based programs. Students are more likely to use available resources when they perceive low-carbon behavior as meaningful and consistent with the values of their university community.

Thus, improving behavioral control should not be viewed only as a technical or infrastructural issue but also as a process supported by collective environmental identity.

5.4.4 Establishing Long-Term Institutional Mechanisms for Low-Carbon Behavior

The findings of this study suggest that sustainable carbon reduction behavior requires continuous reinforcement rather than short-term environmental campaigns. Since collective identity develops through repeated social interaction and shared experiences, universities should establish long-term institutional mechanisms to maintain students' engagement with low-carbon practices.

Universities can integrate sustainability into student development programs, establish green student ambassador systems, encourage cooperation between academic departments and environmental organizations, and include carbon reduction activities within campus culture-building initiatives.

Furthermore, universities may consider creating a long-term recognition system for environmentally responsible groups, such as annual “Green Faculty Awards” or “Low-Carbon Pioneer Group Awards.” These mechanisms can reinforce the perception that carbon reduction represents an important value of the university community rather than a temporary activity.

By institutionalizing low-carbon values and practices, universities can strengthen collective identity formation and encourage students to maintain environmentally responsible behaviors beyond individual campaigns or specific activities.

5.5 Summary

Overall, the practical implications of this study emphasize that promoting carbon reduction behavior among university students requires a shift from individual-focused environmental education toward identity-based and community-oriented interventions. The findings demonstrate that collective identity is a key mechanism connecting environmental cognition with actual behavior. Therefore, universities should create conditions in which students not only understand the importance of carbon reduction but also perceive themselves as active members of a low-carbon community.

Through developing low-carbon identities, strengthening peer-based norms, improving behavioral conditions, and establishing long-term institutional support, universities can more effectively encourage sustainable behavioral transformation among students.

5.6 Research Limitations

Although this study provides theoretical and practical contributions by integrating the Theory of Planned Behavior (TPB) and Social Identity Theory to explain carbon reduction behavior among university students studying in Thailand, several limitations should be acknowledged. These limitations do not undermine the value of the findings but provide important directions for future research to further improve the understanding of sustainable behavior formation.

5.6.1 Limitations of Sample Representativeness

The first limitation concerns the representativeness of the sample. This study focused on university students studying in Thailand, including both Thai domestic students and Chinese international students. This sampling approach reflects the multicultural characteristics of Thai higher education institutions; however, the proportion of Chinese international students was relatively higher than Thai domestic students in the final sample.

Therefore, the findings should be interpreted with caution when generalizing the results to all university students in Thailand. Although the supplementary nationality comparison analysis showed that Thai and Chinese students demonstrated similar patterns in major psychological constructs, including behavioral attitude, subjective norm, perceived behavioral control, and collective identity, differences were identified in actual carbon reduction behavior.

This finding suggests that cultural background, previous environmental experiences, and social contexts may influence the process through which environmental cognition is translated into actual behavioral practices. Future studies should employ more balanced sampling strategies and include students from a wider range of Thai universities, regions, and cultural backgrounds to improve the generalizability of the findings.

5.6.2 Limitations of Research Design

The second limitation relates to the cross-sectional research design adopted in this study. The data were collected at a single point in time; therefore, although the structural model identified significant relationships among behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior, causal relationships cannot be fully established.

Environmental attitudes, social identities, and behaviors may change over time due to educational experiences, social interactions, environmental campaigns, and changes in campus environments. Therefore, the current findings mainly demonstrate the relationships among variables rather than long-term behavioral development processes.

Future research could adopt longitudinal research designs to examine how collective identity develops over time and whether identity-based environmental motivation can produce sustained changes in carbon reduction behavior. Experimental studies could also be conducted to evaluate whether interventions such as low-carbon identity programs or sustainability campaigns effectively strengthen students' environmental behaviors.

5.6.3 Limitations of Behavioral and Contextual Factors

The third limitation concerns the complexity of carbon reduction behavior. Although this study extended TPB by incorporating collective identity, carbon reduction behavior remains influenced by multiple psychological, social, and contextual factors.

The structural model explained 26.2% of the variance in carbon reduction behavior ($R^2 = 0.262$), indicating that the proposed framework provides meaningful explanatory insight but does not capture all possible determinants of low-carbon actions. Other factors, such as environmental knowledge, moral responsibility, personal environmental values, previous environmental experiences, economic considerations, and institutional support, may also influence students' behaviors.

Additionally, although this study considered the role of collective identity within the Thai higher education context, cultural differences may influence how individuals interpret group belonging and environmental responsibility. Future research should further investigate how cultural orientation, social values, and institutional environments interact with collective identity to shape environmental behaviors.

5.7 Future Research Directions

Based on the limitations discussed above, several directions are suggested for future research to further develop the theoretical and empirical understanding of carbon reduction behavior.

5.7.1 Expanding Sample Diversity and Cross-Cultural Comparison

Future research should continue to examine the applicability of the TPB–collective identity framework across different populations and cultural contexts. Although this study focused on university students studying in Thailand and included both Thai domestic students and Chinese international students, the sample distribution between nationality groups was not completely balanced.

Future studies could collect data from a larger number of universities and include students from different cultural backgrounds to improve representativeness. Cross-cultural comparative research could further examine whether the influence of collective identity differs between collectivist and individualistic societies.

Furthermore, future research may apply multi-group structural equation modeling (MG-SEM) and measurement invariance testing to examine whether the structural relationships among TPB factors, collective identity, and carbon reduction behavior vary across nationality or cultural groups.

5.7.2 Applying Longitudinal and Experimental Research Designs

Future research should consider adopting longitudinal and experimental approaches to better understand the development of carbon reduction behavior.

Longitudinal studies could examine whether collective identity gradually develops through participation in environmental activities and whether such identity formation leads to sustained behavioral changes over time. This approach would provide stronger evidence regarding the causal relationship between identity formation and environmental behavior.

Experimental studies could also evaluate the effectiveness of identity-based interventions. For example, researchers could examine whether programs such as low-carbon student identity campaigns, green student organizations, or campus sustainability competitions can strengthen collective identity and encourage actual carbon reduction behavior.

Such approaches would provide stronger empirical support for the behavioral mechanisms proposed in the TPB–collective identity framework.

5.7.3 Incorporating Additional Psychological and Contextual Factors

Although this study extends TPB by introducing collective identity, the explained variance of carbon reduction behavior indicates that additional factors should be considered in future research.

Future studies may incorporate psychological factors such as environmental knowledge, moral norms, environmental concern, personal responsibility, and environmental self-identity. These variables may provide further explanations regarding why individuals develop and maintain sustainable behaviors.

In addition, contextual factors should be included, such as university sustainability policies, campus environmental facilities, social support networks, and environmental education programs. These factors may influence whether students can successfully transform environmental intentions and identity into actual behaviors.

By integrating additional individual and contextual variables, future research can develop a more comprehensive model of carbon reduction behavior.

5.8 Conclusion

This study aimed to develop a more comprehensive understanding of carbon reduction behavior among university students studying in Thailand by integrating the Theory of Planned Behavior and Social Identity Theory. While previous studies have primarily explained environmental behavior from an individual cognitive perspective, this study introduced collective identity as an additional psychological mechanism to explain how personal cognition and social influence are transformed into actual low-carbon actions.

The findings demonstrate that carbon reduction behavior is shaped by the interaction between individual cognition, social influence, and identity-based motivation. Behavioral attitude, subjective norm, and perceived behavioral control provide important explanations of students' environmental actions, while collective identity further reveals the role of group belonging and shared values in strengthening behavioral engagement.

More importantly, this study demonstrates that collective identity functions as a psychological bridge connecting TPB factors with carbon reduction behavior. This finding suggests that sustainable actions are not only driven by personal evaluation or perceived ability but also by whether individuals perceive environmental responsibility as part of their collective identity.

From a theoretical perspective, this study extends TPB by incorporating a social identity mechanism and provides empirical evidence from the Thai higher education context. From a practical perspective, the findings suggest that universities should promote carbon reduction behavior through identity-based approaches, supportive social environments, and long-term sustainability initiatives.

Overall, this study contributes to a deeper understanding of how university students develop and maintain carbon reduction behaviors. The integrated TPB–collective identity framework provides a valuable perspective for future environmental behavior research and offers practical guidance for universities seeking to cultivate sustainable campus communities.

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APPENDIXES

APPENDIX A

Questionnaire

Appendix A: Questionnaire

Questionnaire Survey: Low-Carbon Behavior and Social Identity

Please indicate the extent to which you agree with each statement based on your actual views and experiences. Use the following 7-point Likert scale:

1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neutral, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree.

Basic Information

1. University Name: _____

2. Have you taken any courses related to carbon reduction behavior or sustainable development?

□ Yes □ No

3. Have you participated in any environmental protection groups or volunteer activities?

□ Yes □ No

4. Gender:

□ Male □ Female □ Other/Unwilling to disclose

5. Age: _____

6. Academic Year:

□ Freshman □ Sophomore □ Junior □ Senior □ Graduate Student

7.Nationality:

□ Thailand □ China □ Other

8. Major Type:

□ Arts □ Science/Engineering □ Business

□ Medicine □ Arts and Sports □ Other

9. Are you familiar with carbon reduction behaviors? (Carbon reduction behaviors: reducing greenhouse gas emissions through energy conservation, low-carbon travel, green consumption, etc.)

□ A. Very familiar with (able to explain clearly and provide examples)

□ B. Have a relatively good understanding (know the general meaning and some examples)

□ C. I've heard of it, but I don't know the specifics.

□ D. Never heard of it

10. What are your main channels for learning about carbon reduction efforts? (Multiple selections allowed)

□ A. School curriculum/classroom learning (reading, textbooks, teacher lectures)

□ B. Campus Publicity/Regulations (Posters, Announcements, Waste Sorting and Energy Conservation Tips, etc.)

□ C. Social media/short video platforms (such as Facebook/Instagram/TikTok, etc.)

□ D. Forums/Communities/Online Communities (such as Reddit, Line groups, school communities, etc.)

□ E. Environmental protection clubs/volunteer activities/campus green activities

□ F. Communication with family/friends/peers

□ G. News media/government or institutional publicity

□ H. Other: _____ (Fill in the blank)

Part Two: Attitude

1. I believe that low-carbon behaviors have a significant positive impact on the environment.

2. I believe that energy conservation and emission reduction can help reduce global warming.

3. I believe that practicing low-carbon behavior is meaningful for sustainable development.

4. I believe that adopting low-carbon behavior is a responsible choice for university students.

5. I believe that low-carbon behaviors are worth practicing even if they may cause some inconvenience.

6. I believe that everyone has a responsibility to reduce carbon emissions in daily life.

Part Three: Subjective Norms

1. People who are important to me think that I should engage in low-carbon behavior.

2. My classmates and friends encourage me to practice low-carbon behavior in daily life.

3. My teachers or university staff support students in adopting low-carbon behavior.

4. My family supports me in saving energy, reducing waste, and choosing environmentally friendly options.

5. People around me would approve if I practiced low-carbon behavior in daily life.

6. I feel encouraged by people around me to make more environmentally friendly choices.

Part Four: Perceived Behavioral Control

1. I believe I have the ability to choose low-carbon travel methods in daily life.

2. I believe I can take energy-saving actions to reduce energy waste.

3. I know how to choose green and environmentally friendly products.

4. I believe I can reduce unnecessary resource consumption in my daily life.

5. I believe that practicing low-carbon behavior is feasible for me under my current living conditions.

6. Even when low-carbon behavior requires extra effort, I believe I can still do it.

Part Five: Collective Identity

1. I see low-carbon behavior as part of the shared values of university students.

2. Being low-carbon is consistent with my identity as a responsible university student.

3. I feel a sense of belonging when I participate in low-carbon activities with other students.

4. I identify with university students who regard carbon reduction as a shared responsibility.

5. Low-carbon behavior reflects the kind of student group I want to belong to.

6. Practicing low-carbon behavior makes me feel connected with other environmentally responsible students.

Part Six: Carbon Reduction Behavior

1. In the past month, I have reduced the use of private cars or ride-hailing services and chosen public transportation, walking, or cycling whenever possible.

2. In the past month, I have reduced my use of single-use plastic products, such as plastic bags, disposable cups, or plastic straws.

3. In the past month, I have turned off unnecessary lights, air conditioners, chargers, or other electrical appliances to save energy.

4. In the past month, I have chosen environmentally friendly or low-carbon products when making purchases whenever possible.

5. In the past month, I have participated in recycling, waste sorting, or resource-saving activities in my daily life.

6. In the past month, I have consciously reduced behaviors that may increase carbon emissions in my daily life.

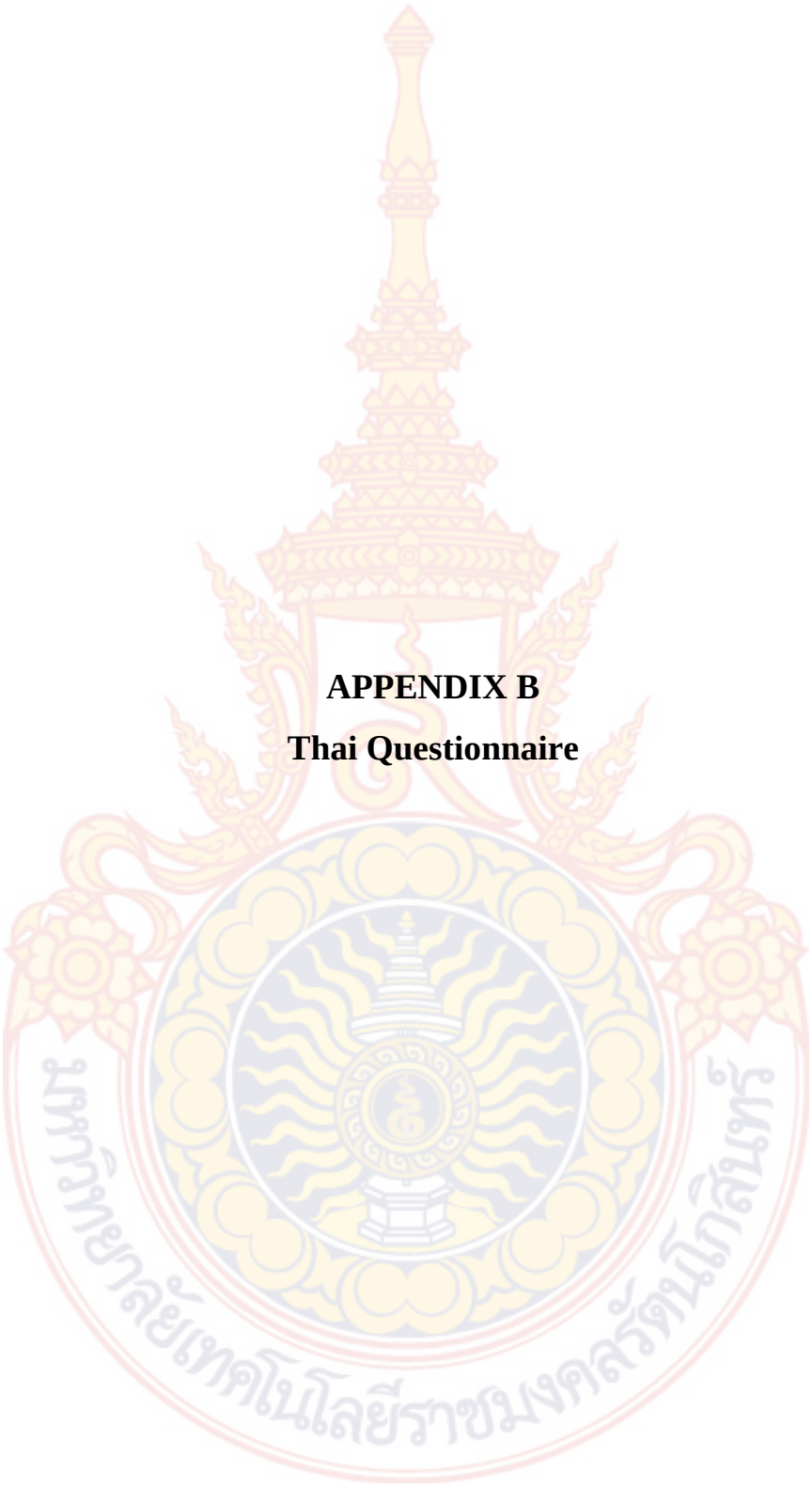
Open-ended Questions

In your opinion, what role should university students play in promoting low-carbon behavior on campus and in society?

What difficulties do you face when practicing low-carbon behavior in daily life, and what suggestions do you have for encouraging university students to take more carbon reduction action

APPENDIX B

Thai Questionnaire



แบบสอบถาม: พฤติกรรมลดคาร์บอนและอัตลักษณ์ทางสังคม

โปรดระบุระดับความเห็นด้วยของคุณกับแต่ละข้อความตามมุมมองและประสบการณ์จริงของคุณ

โดยใช้มาตราส่วนลิเคิร์ต 7 ระดับดังต่อไปนี้:

1 = ไม่เห็นด้วยอย่างยิ่ง, 2 = ไม่เห็นด้วย, 3 = ไม่เห็นด้วยเล็กน้อย, 4 = เป็นกลาง, 5 = เห็นด้วยเล็กน้อย, 6 = เห็นด้วย, 7 = เห็นด้วยอย่างยิ่ง

ข้อมูลพื้นฐาน

1. ชื่อมหาวิทยาลัย: _____

2. คุณเคยเรียนหลักสูตรใด ๆ ที่เกี่ยวข้องกับพฤติกรรมลดคาร์บอนหรือการพัฒนาอย่างยั่งยืนหรือไม่?

☐ ใช่ ☐ ไม่

3. คุณเคยเข้าร่วมกลุ่มอนุรักษ์สิ่งแวดล้อมหรือกิจกรรมอาสาสมัครใด ๆ หรือไม่?

☐ ใช่ ☐ ไม่ใช่

4. เพศ:

☐ ชาย ☐ หญิง ☐ อื่นๆ/ไม่ประสงค์จะเปิดเผย

5. อายุ: _____

6. ปีการศึกษา:

☐ ปี 1 ☐ ปี 2 ☐ ปี 3 ☐ ปี 4 ☐ นักศึกษาปริญญาโท

7. สัญชาติ:

☐ ไทย ☐ จีน ☐ อื่นๆ

8. ประเภทสาขาวิชา:

☐ ศิลปศาสตร์ ☐ วิทยาศาสตร์/วิศวกรรมศาสตร์ ☐ บริหารธุรกิจ ☐ แพทยศาสตร์

☐ ศิลปะและกีฬา ☐ อื่นๆ

9. คุณคุ้นเคยกับพฤติกรรมการลดคาร์บอนหรือไม่? (พฤติกรรมการลดคาร์บอน: การลดการปล่อยก๊าซเรือนกระจกผ่านการประหยัดพลังงาน การเดินทางที่ปล่อยคาร์บอนต่ำ การบริโภคที่เป็นมิตรต่อสิ่งแวดล้อม ฯลฯ)

☐ ก. คุ้นเคยเป็นอย่างดี (สามารถอธิบายได้อย่างชัดเจนและยกตัวอย่างได้)

☐ ข. มีความเข้าใจค่อนข้างดี (รู้ความหมายทั่วไปและตัวอย่างบางส่วน)

☐ ค. เคยได้ยิน แต่ไม่ทราบรายละเอียด

☐ ง. ไม่เคยได้ยินมาก่อน

10. ช่องทางหลักของคุณในการเรียนรู้เกี่ยวกับความพยายามในการลดคาร์บอนคืออะไร? (สามารถเลือกได้หลายข้อ)

☐ ก. หลักสูตรการเรียนการสอน/การเรียนรู้ในห้องเรียน (การอ่าน ตำราเรียน การบรรยายของครู)

☐ ข. การประชาสัมพันธ์/ระเบียบข้อบังคับของมหาวิทยาลัย (โปสเตอร์ ประกาศ เคล็ดลับ การคัดแยกขยะและการประหยัดพลังงาน ฯลฯ)

☐ ค. สื่อสังคมออนไลน์/แพลตฟอร์มวิดีโอสั้น (เช่น Facebook/Instagram/TikTok ฯลฯ)

☐ ง. ฟอรัม/ชุมชน/ชุมชนออนไลน์ (เช่น Reddit กลุ่ม Line ชุมชนของมหาวิทยาลัย ฯลฯ)

☐ จ. ชมรมอนุรักษ์สิ่งแวดล้อม/กิจกรรมอาสาสมัคร/กิจกรรมสีเขียวของมหาวิทยาลัย

☐ ฉ. การสื่อสารกับครอบครัว/เพื่อน/คนรู้จัก

☐ ช. สื่อข่าว/การประชาสัมพันธ์ของรัฐบาลหรือสถาบัน

☐ ซ. อื่นๆ: _____ (เติมในช่องว่าง)

ส่วนที่สอง: ทัศนคติ

1. ฉันเชื่อว่าพฤติกรรมลดคาร์บอนมีผลกระทบเชิงบวกอย่างมากต่อสิ่งแวดล้อม
2. ฉันเชื่อว่าการประหยัดพลังงานและการลดการปล่อยก๊าซเรือนกระจกสามารถช่วยลดภาวะโลกร้อนได้
3. ฉันเชื่อว่าการปฏิบัติตามพฤติกรรมคาร์บอนต่ำมีความหมายต่อการพัฒนาอย่างยั่งยืน
4. ฉันเชื่อว่าการนำพฤติกรรมคาร์บอนต่ำมาใช้เป็นทางเลือกที่รับผิดชอบสำหรับนักศึกษามหาวิทยาลัย
5. ฉันเชื่อว่าพฤติกรรมคาร์บอนต่ำนั้นคุ้มค่าที่จะปฏิบัติตาม แม้ว่าอาจทำให้เกิดความไม่สะดวกบ้างก็ตาม
6. ฉันเชื่อว่าทุกคนมีหน้าที่รับผิดชอบในการลดการปล่อยก๊าซคาร์บอนในชีวิตประจำวัน

ส่วนที่สาม: บรรทัดฐานเชิงอัตวิสัย

1. คนที่สำคัญกับฉันคิดว่าฉันควรมีส่วนร่วมในพฤติกรรมคาร์บอนต่ำ

2. เพื่อนร่วมชั้นและเพื่อนของฉันสนับสนุนให้ฉันปฏิบัติตามพฤติกรรมคาร์บอนต่ำในชีวิตประจำวัน

3. อาจารย์หรือเจ้าหน้าที่มหาวิทยาลัยของฉันสนับสนุนนักศึกษาในการนำพฤติกรรมคาร์บอนต่ำมาใช้

4. ครอบครัวของฉันสนับสนุนฉันในการประหยัดพลังงาน ลดขยะ และเลือกใช้ทางเลือก ที่เป็นมิตรต่อสิ่งแวดล้อม

5. คนรอบข้างฉันจะเห็นด้วยหากฉันปฏิบัติตามพฤติกรรมคาร์บอนต่ำในชีวิตประจำวัน

6. ฉันรู้สึกได้รับการสนับสนุนจากคนรอบข้างให้เลือกใช้สิ่งที่เป็นมิตรต่อสิ่งแวดล้อมมากขึ้น

ส่วนที่สี่: การรับรู้การควบคุมพฤติกรรม

1. ฉันเชื่อว่าฉันมีความสามารถในการเลือกวิธีการเดินทางที่ปล่อยคาร์บอนต่ำในชีวิตประจำวัน

2. ฉันเชื่อว่าฉันสามารถดำเนินการประหยัดพลังงานเพื่อลดการสิ้นเปลืองพลังงานได้

3. ฉันรู้วิธีเลือกผลิตภัณฑ์ที่เป็นมิตรต่อสิ่งแวดล้อม

4. ฉันเชื่อว่าฉันสามารถลดการบริโภคทรัพยากรที่ไม่จำเป็นในชีวิตประจำวันของฉันได้

5. ฉันเชื่อว่าการปฏิบัติตามพฤติกรรมที่ปล่อยคาร์บอนต่ำนั้นเป็นไปได้สำหรับฉันภายใต้สภาพความเป็นอยู่ปัจจุบันของฉัน

6. แม้ว่าพฤติกรรมที่ปล่อยคาร์บอนต่ำจะต้องการความพยายามเพิ่มเติม ฉันก็เชื่อว่าฉันยังสามารถทำได้

ส่วนที่ห้า: อัตลักษณ์ร่วม

1. ฉันมองว่าพฤติกรรมที่ปล่อยคาร์บอนต่ำเป็นส่วนหนึ่งของค่านิยมร่วมกันของนักศึกษามหาวิทยาลัย

2. การมีพฤติกรรมที่ปล่อยคาร์บอนต่ำสอดคล้องกับอัตลักษณ์ของฉันในฐานะนักศึกษามหาวิทยาลัยที่มีความรับผิดชอบ

3. ฉันรู้สึกถึงความเป็นส่วนหนึ่งเมื่อฉันเข้าร่วมกิจกรรมที่ปล่อยคาร์บอนต่ำกับนักศึกษาคนอื่นๆ

4. ฉันรู้สึกเชื่อมโยงกับนักศึกษาในมหาวิทยาลัยที่มองว่าการลดคาร์บอนเป็นความรับผิดชอบร่วมกัน

5. พฤติกรรมลดคาร์บอนสะท้อนให้เห็นถึงกลุ่มนักศึกษาที่ฉันอยากเป็นส่วนหนึ่ง

6. การปฏิบัติตามพฤติกรรมลดคาร์บอนทำให้ฉันรู้สึกเชื่อมโยงกับนักศึกษาที่มีความรับผิดชอบต่อสิ่งแวดล้อมคนอื่นๆ

ส่วนที่หก: พฤติกรรมลดคาร์บอน

1. ในเดือนที่ผ่านมา ฉันลดการใช้รถยนต์ส่วนตัวหรือบริการเรียกรถ และเลือกใช้ระบบขนส่งสาธารณะ การเดิน หรือการปั่นจักรยานทุกครั้งที่ทำได้

2. ในเดือนที่ผ่านมา ฉันลดการใช้ผลิตภัณฑ์พลาสติกแบบใช้ครั้งเดียวทิ้ง เช่น ถุงพลาสติก แก้วแบบใช้แล้วทิ้ง หรือหลอดพลาสติก

3. ในเดือนที่ผ่านมา ฉันปิดไฟ เครื่องปรับอากาศ เครื่องชาร์จ หรือเครื่องใช้ไฟฟ้าอื่นๆ ที่ไม่จำเป็น เพื่อประหยัดพลังงาน

4. ในเดือนที่ผ่านมา ฉันเลือกซื้อผลิตภัณฑ์ที่เป็นมิตรต่อสิ่งแวดล้อมหรือผลิตภัณฑ์ลดคาร์บอนทุกครั้งที่ทำได้

5. ในเดือนที่ผ่านมา ฉันมีส่วนร่วมในกิจกรรมรีไซเคิล การคัดแยกขยะ หรือการประหยัดทรัพยากร ในชีวิตประจำวันของฉัน

6. ในเดือนที่ผ่านมาตลอดเดือนที่ผ่านมาฉันได้ลดพฤติกรรมที่อาจเพิ่มการปล่อยก๊าซคาร์บอนในชีวิตประจำวันลงอย่างมีสติ

คำถามปลายเปิด

ในความคิดของคุณนักศึกษามหาวิทยาลัยควรมีบทบาทอย่างไรในการส่งเสริมพฤติกรรมลดคาร์บอนในมหาวิทยาลัยและในสังคม?

คุณประสบปัญหาอะไรบ้างเมื่อปฏิบัติตามพฤติกรรมลดคาร์บอนในชีวิตประจำวันและคุณมีข้อเสนอแนะอะไรบ้างในการกระตุ้นให้นักศึกษามหาวิทยาลัยดำเนินการลดคาร์บอนมากขึ้น?

APPENDIX C

Article

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From Collective Identity to Individual Action: The Logic Behind Thai University Students' Carbon Reduction Behavior

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Abstract: This study aimed to examine the formation mechanism of carbon reduction behavior among university students in Thailand by integrating the Theory of Planned Behavior and Social Identity Theory. A quantitative cross-sectional survey was conducted using a structured questionnaire. Data were collected from university students studying in Thailand, and 347 valid responses were retained after data screening. SPSS and AMOS were used to conduct descriptive statistics, reliability analysis, confirmatory factor analysis, structural equation modeling, and Bootstrap mediation analysis. The results showed that behavioral attitude, subjective norm, perceived behavioral control, and collective identity all had significant positive effects on carbon reduction behavior. Collective identity had the strongest direct effect. The Bootstrap results further showed that collective identity significantly mediated the relationships between behavioral attitude and carbon reduction behavior, subjective norm and carbon reduction behavior, and perceived behavioral control and carbon reduction behavior. These findings indicate that carbon reduction behavior is shaped not only by individual cognitive factors and perceived social influence, but also by the internalization of low-carbon values as part of students' shared group identity.

Keywords: Carbon Reduction Behavior; Collective Identity; Theory of Planned Behavior; Social Identity Theory; University Students; Thailand

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1. Introduction

1.1 Research Background

Climate change has become a major global challenge, and reducing greenhouse gas emissions requires not only governmental policies and technological innovation but also changes in individual daily behavior. Carbon reduction behavior includes energy conservation, low-carbon transportation, green consumption, waste reduction, and other actions that help decrease environmental impact. Individual behavioral change is therefore an important component of broader climate mitigation efforts.

University students are an important group in promoting carbon reduction because their environmental values, consumption habits, and lifestyles are still developing. Their behavior may also influence peers, families, and wider society. In Thailand, universities have increasingly promoted green campuses, environmental education, and low-carbon activities. However, students' environmental awareness does not always translate into stable carbon reduction behavior. Their actions may be influenced by personal evaluations, social expectations, available resources, and group relationships.

The Theory of Planned Behavior provides a useful framework for explaining this process. According to Ajzen (1991), behavioral attitude, subjective norm, and perceived behavioral control are important predictors of individual behavior. Students are more likely to engage in carbon reduction behavior when they consider such behavior valuable, perceive support from important others, and believe that they have sufficient ability and opportunities to perform it. Previous studies have confirmed that these psychological factors are closely related to pro-environmental behavior (Bamberg & Möser, 2007; Steg & Vlek, 2009).

However, the Theory of Planned Behavior mainly emphasizes individual decision-making and provides only a limited explanation of group belonging and identity internalization. Social Identity Theory suggests that individuals define themselves partly through their membership in social groups and tend to adopt attitudes and behaviors consistent with relevant group values and norms (Hornsey, 2008). When students perceive carbon reduction as a shared responsibility and a common value of the university community, they may be more likely to internalize low-carbon norms and maintain corresponding behavior. Collective identity may therefore serve as an important psychological mechanism connecting individual cognition with actual action (Fielding & Hornsey, 2016; Fritsche et al., 2018).

Although previous studies have examined planned behavior factors and pro-environmental behavior, limited research has integrated collective identity into the Theory of Planned Behavior to explain the carbon reduction behavior of university students in Thailand. Therefore, this study examines the direct effects of behavioral attitude, subjective norm, and perceived behavioral control on carbon reduction behavior and further investigates the direct and mediating roles of collective

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identity.

1.2 Research Gap and Purpose

Previous studies have widely applied the Theory of Planned Behavior to explain pro-environmental behavior. Behavioral attitude, subjective norm, and perceived behavioral control have been identified as important predictors of environmental action (Ajzen, 1991; Bamberg & Möser, 2007). However, this approach primarily emphasizes individual cognitive evaluation and does not fully explain how group belonging and shared identity transform environmental beliefs into stable behavior.

Social identity research suggests that individuals are more likely to adopt pro-environmental behavior when environmental responsibility is regarded as part of the values and norms of an important group (Fielding & Hornsey, 2016; Fritsche et al., 2018). Nevertheless, relatively few studies have integrated collective identity with the Theory of Planned Behavior to examine carbon reduction behavior. Existing research also tends to focus on behavioral intention or a single environmental action, while limited attention has been paid to students' actual behaviors across energy conservation, low-carbon transportation, and green consumption.

In addition, empirical evidence concerning carbon reduction behavior among university students in Thailand remains limited. The group-oriented campus environment and the relatively collectivist social context make Thai university students particularly suitable for examining the role of collective identity. Therefore, this study integrates the Theory of Planned Behavior and Social Identity Theory to investigate how behavioral attitude, subjective norm, and perceived behavioral control influence carbon reduction behavior. It also examines whether collective identity directly affects carbon reduction behavior and mediates the relationships between the three planned behavior factors and actual carbon reduction behavior.

1.3 Research Questions

Based on the research gap, this study addresses the following questions:

RQ1: How do behavioral attitude, subjective norm, and perceived behavioral control affect the carbon reduction behavior of Thai university students?

RQ2: How does collective identity affect the carbon reduction behavior of Thai university students?

RQ3: Does collective identity mediate the relationships between behavioral attitude, subjective norm, perceived behavioral control, and carbon reduction behavior?

1.4 Research Objectives

Accordingly, the objectives of this study are:

RO1:To identify the principal psychological determinants of carbon reduction behavior among Thai university students by evaluating the relative effects of behavioral attitude, subjective norm, and perceived behavioral control.

RO2: To clarify the contribution of group belonging and shared low-carbon values to individual action by incorporating collective identity into the explanation of students' carbon reduction behavior.

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RO3: To reveal the psychological transformation mechanism from individual cognition to actual low-carbon action by testing collective identity as a mediating mechanism within the proposed research model.

1.5 Research Significance

1.5.1 Theoretical Significance

This study extends the application of the Theory of Planned Behavior by incorporating collective identity into the explanation of carbon reduction behavior. Traditional TPB mainly focuses on behavioral attitude, subjective norm, and perceived behavioral control at the individual level (Ajzen, 1991). By introducing collective identity, this study further explains how group belonging and shared low-carbon values may strengthen the transformation from individual cognition to actual behavior.

This study also contributes to environmental behavior research by integrating the Theory of Planned Behavior and Social Identity Theory within a single framework. The proposed model helps clarify whether carbon reduction behavior is influenced only by individual psychological factors or is also reinforced through group identification and shared responsibility (Fielding & Hornsey, 2016; Fritsche et al., 2018).

1.5.2 Practical Significance

The findings may provide practical guidance for universities in promoting carbon reduction behavior among students. Universities can improve low-carbon education not only by increasing environmental knowledge but also by strengthening peer support, campus norms, and students' sense of collective responsibility.

The results may also support the design of campus policies and environmental activities. Green campus campaigns, student organizations, volunteer programs, and peer-led low-carbon initiatives may help students view carbon reduction as a shared group value rather than only an individual responsibility. This may improve the continuity and effectiveness of students' low-carbon practices.

2. Literature Review and Theoretical Foundation

2.1 Carbon Reduction Behavior

Carbon reduction behavior refers to individual actions that reduce energy consumption, resource use, and greenhouse gas emissions. It includes energy conservation, low-carbon transportation, green consumption, waste reduction, recycling, and reduced use of disposable products (Stern, 2000; Steg & Vlek, 2009). These behaviors represent practical efforts through which individuals contribute to climate change mitigation and sustainable development.

Environmental knowledge alone does not necessarily lead to actual environmental action. Individuals may understand environmental problems but fail to change their behavior because of inconvenience, additional costs, insufficient resources, weak social support, or limited perceived control. Carbon reduction behavior should therefore be understood as the result of interactions among individual evaluation, social influence, perceived feasibility, and situational conditions (Kollmuss & Agyeman, 2002).

University students are an

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important group for studying carbon reduction behavior because their values, lifestyles, and consumption habits are still developing. Their daily activities involve frequent decisions related to electricity use, transportation, consumption, and waste management. These behaviors may also be affected by university policies, peer expectations, environmental education, and campus culture. In this study, carbon reduction behavior refers to actual actions undertaken by university students in their daily lives rather than their future behavioral intentions.

2.2 Theory of Planned Behavior

The Theory of Planned Behavior is widely used to explain how individual cognition influences behavior. According to Ajzen (1991), behavior is primarily determined by behavioral intention, which is shaped by behavioral attitude, subjective norm, and perceived behavioral control. Perceived behavioral control may also directly influence actual behavior when it accurately reflects the resources and opportunities available to the individual.

Behavioral attitude refers to an individual's positive or negative evaluation of performing a particular behavior. Subjective norm reflects the perceived expectations and support of significant others. Perceived behavioral control represents an individual's judgment of whether they possess the necessary abilities, resources, and opportunities to perform the behavior (Ajzen, 1991).

The theory has been extensively applied to pro-environmental behavior. Previous research has demonstrated that attitudes, social norms, and perceived control are important psychological determinants of recycling, green consumption, energy conservation, and other environmentally responsible actions (Bamberg & Möser, 2007; Steg & Vlek, 2009). Accordingly, students who evaluate carbon reduction positively, perceive support from important others, and believe that low-carbon actions are feasible are more likely to engage in carbon reduction behavior.

However, the Theory of Planned Behavior mainly emphasizes individual cognitive evaluation. Although subjective norm represents social influence, it does not fully explain how individuals internalize group values or define environmental behavior as part of their shared identity. Therefore, Social Identity Theory is introduced to provide an additional explanation of the group-based psychological process underlying carbon reduction behavior.

2.3 Social Identity Theory and Collective Identity

Social Identity Theory proposes that individuals define themselves not only through personal characteristics but also through membership in social groups. When group membership becomes important to an individual's self-concept, the individual is more likely to adopt attitudes and behaviors consistent with the values and norms of that group (Hornsey, 2008).

Collective identity refers to an individual's sense of belonging to a group and identification with its shared values, responsibilities, and behavioral standards. In the environmental context, individuals with stronger collective identity may view environmental

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protection as something that "we" should do rather than merely a personal choice. This identity-based understanding may encourage individuals to internalize environmental norms and maintain consistent pro-environmental behavior.

Fielding and Hornsey (2016) argued that social identity processes influence how people understand environmental problems and respond to environmental norms. Similarly, the Social Identity Model of Pro-Environmental Action proposes that group identification, group norms, collective efficacy, and related identity processes can promote pro-environmental action (Fritsche et al., 2018).

Collective identity differs conceptually from subjective norm. Subjective norm concerns whether individuals perceive that others expect or encourage them to behave in a particular way. Collective identity concerns whether individuals regard that behavior as part of the shared values and identity of their group. Therefore, collective identity may provide a deeper explanation of how external social expectations become internalized and transformed into sustained personal action.

In this study, collective identity refers to the extent to which university students view carbon reduction as part of the shared values, responsibilities, and identity of the university student community.

2.4 Integration of the Theory of Planned Behavior and Social Identity Theory

The Theory of Planned Behavior and Social Identity Theory explain different but complementary aspects of carbon reduction behavior. The Theory of Planned Behavior explains how personal evaluation, perceived social expectations, and perceived feasibility contribute to behavioral action. Social Identity Theory explains how group belonging and shared values strengthen and internalize these psychological influences.

Behavioral attitude may contribute to collective identity because students who regard carbon reduction as meaningful and responsible may be more willing to accept low-carbon values as part of their group identity. Subjective norm may strengthen collective identity when support from classmates, teachers, universities, and other important groups signals that carbon reduction is a shared behavioral expectation. Perceived behavioral control may also contribute to collective identity because behaviors that are considered practical and achievable are more likely to become accepted as sustainable group standards.

Collective identity may subsequently translate these individual-level psychological factors into actual carbon reduction behavior. When students perceive carbon reduction as consistent with "who we are" as responsible university students, low-carbon action may become more stable than behavior based only on personal preference or external pressure. Collective identity therefore serves as a psychological bridge between individual cognition and actual action.

The integrated framework provides a more comprehensive explanation of

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carbon reduction behavior than either theory alone. The Theory of Planned Behavior identifies the cognitive and social foundations of behavior, whereas Social Identity Theory explains how these foundations are internalized through group membership and shared responsibility.

2.5 Research Model

Based on the preceding theoretical discussion, this study proposes an integrated research model combining the Theory of Planned Behavior and Social Identity Theory. The model includes behavioral attitude, subjective norm, and perceived behavioral control as independent variables, collective identity as a mediating variable, and carbon reduction behavior as the dependent variable.

The research model contains two types of relationships. First, behavioral attitude, subjective norm, perceived behavioral control, and collective identity are expected to have direct effects on carbon reduction behavior. These paths examine whether individual cognition, perceived social influence, perceived feasibility, and group identification directly promote actual low-carbon action.

Second, behavioral attitude, subjective norm, and perceived behavioral control are expected to influence carbon reduction behavior indirectly through collective identity. These paths examine whether individual psychological factors become more effectively transformed into actual behavior when students internalize carbon reduction as part of shared group values and responsibilities.

Accordingly, the model explains carbon reduction behavior as a process moving from individual cognition to collective identification and finally to actual low-carbon action.

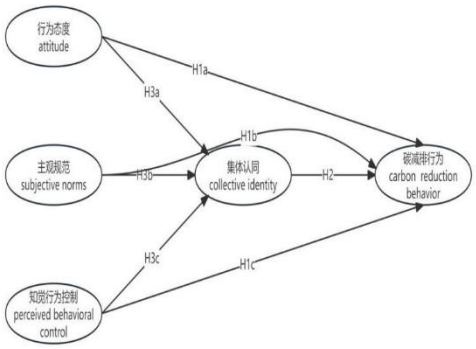

Figure 2.1 Research Model

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2.6 Research Hypotheses

H1a: Behavioral attitude has a significant positive effect on carbon reduction behavior.

H1b: Subjective norm has a significant positive effect on carbon reduction behavior.

H1c: Perceived behavioral control has a significant positive effect on carbon reduction behavior.

H2: Collective identity has a significant positive effect on carbon reduction behavior.

H3a: Collective identity mediates the relationship between behavioral attitude and carbon reduction behavior.

H3b: Collective identity mediates the relationship between subjective norm and carbon reduction behavior.

H3c: Collective identity mediates the relationship between perceived behavioral control and carbon reduction behavior.

3. Research Methodology

3.1 Research Design and Data Collection

This study employed a cross-sectional survey method, collecting data from respondents at the same time point. This design is suitable for examining the relationships between attitudes, cognitions, and self-reported behaviors within a specific population (Sedgwick, 2014). A quantitative design was used to measure the research constructs and to statistically test the direct and mediating relationships presented in the model.The target population consisted of university students studying in Thailand. Convenience sampling was used because a complete sampling frame was unavailable and eligible respondents could be efficiently reached through university-related networks (Etikan et al., 2016). The questionnaire was distributed online through student groups, class communication channels, social media communities, and campus organizations. Online surveys can facilitate efficient access to geographically or institutionally dispersed respondents, although researchers must also consider sampling and response-quality limitations (Wright, 2005). Respondents came from multiple universities, academic years, and disciplines to improve sample diversity.

The questionnaire consisted of two sections. The first section collected demographic and background information. The second section measured behavioral attitude, subjective norm, perceived behavioral control, collective identity, and carbon reduction behavior. Each construct contained six items, resulting in 30 measurement items. All items were measured using a seven-point Likert scale ranging from 1, "strongly disagree," to 7, "strongly agree."

Participation was voluntary and anonymous, and respondents were informed that their information would be used only for academic purposes. After responses with substantial missing values, straight-line answering, abnormal completion times, or logical inconsistencies were removed, 347 valid questionnaires were retained for analysis.

3.2 Questionnaire Reliability Test

Before the formal analysis, the internal consistency of the questionnaire was assessed using Cronbach's alpha.

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Cronbach's alpha is commonly used to evaluate the extent to which multiple items consistently measure the same underlying construct. The coefficient should be interpreted together with the number of items and the conceptual structure of the scale rather than being treated as an isolated indicator (Tavakol & Dennick, 2011)

The reliability results showed that Cronbach's alpha was 0.894 for behavioral attitude, 0.895 for subjective norm, 0.895 for perceived behavioral control, 0.881 for collective identity, and 0.883 for carbon reduction behavior. The overall Cronbach's alpha for the 30 measurement items was 0.924.

The construct-level coefficients ranged from 0.881 to 0.895, while the overall coefficient was 0.924. These results indicate strong internal consistency among the measurement items and support the use of the scales in the subsequent validity and structural analyses (Tavakol & Dennick, 2011).

Table 3.1 Questionnaire Reliability Results

Test	Value
Number of respondents	30
Number of items	30
Cronbach's Alpha	0.938

3.3 Data Analysis Methods

The collected data were analyzed using SPSS and AMOS. First, descriptive statistics were used to summarize the respondents' demographic characteristics and the overall levels of the research variables. Frequencies and percentages were reported for categorical variables, while means and standard deviations were calculated for the measurement items and constructs.

Second, Cronbach's alpha was used to evaluate internal consistency. The Kaiser–Meyer–Olkin measure and Bartlett's test of sphericity were then applied to determine whether the data were suitable for factor aalysis. Confirmatory factor analysis was conducted to evaluate the measurement model through standardized factor loadings, composite reliability, average variance extracted, and discriminant validity (Cheung et al., 2024; Fornell & Larcker, 1981).

Third, structural equation modeling was used to test the direct effects of behavioral attitude, subjective norm, perceived behavioral control, and collective identity on carbon reduction behavior. Model fit was assessed using χ^2/df, GFI, CFI, TLI, RMSEA, and other fit indices. Model fit was evaluated using multiple indices, including χ^2/df, GFI, CFI, TLI, and RMSEA. The adequacy of an SEM model should be judged by considering several absolute and incremental fit indices together rather than relying on a single statistic (Iacobucci, 2010).

Finally, the Bootstrap method with 5,000 resamples was used to examine the mediating role of collective identity. An indirect effect was considered significant when its 95% Bootstrap confidence interval did not include zero (Cheung, 2009).

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4. Results and Discussion

4.1 Demographic Characteristics of Respondents

After data screening, 347 valid questionnaires were retained for analysis. The respondents came from 13 universities in Thailand, which increased the diversity of the sample. Mahidol University contributed the largest proportion of respondents (17.9%), followed by Chulalongkorn University (15.0%) and Bangkok University (11.5%).

Regarding gender, 190 respondents were female (54.8%) and 157 were male (45.2%). Most respondents were aged between 18 and 21 years, accounting for 74.6% of the sample. The distribution across academic years was relatively balanced, with each group representing between 18.2% and 21.6% of the sample.

A total of 245 respondents (70.6%) had participated in environmental or sustainability-related courses, while 260 respondents (74.9%) had joined environmental organizations or volunteer activities. In addition, 71.1% of respondents reported that they were familiar with or had a good understanding of carbon reduction behavior. These results indicate that most respondents had relevant educational exposure or practical environmental experience.

Table 4.1 Descriptive Statistical Analysis

Variable	Options	Frequency	Percentage
University	Mahidol University	62	17.9
	Chulalongkorn University	52	15.0
	Bangkok University	40	11.5
	Dhurakij Pundit University	34	9.8
	Krirk University	33	9.5
	Thammasat University	22	6.3
	Kasetsart University	21	6.1
	Bangkok Thonburi University	19	5.5
	Stamford International University	18	5.2
	Srinakharinwirot University	17	4.9
	Silpakorn University	13	3.7
	Assumption University	11	3.2
	Rajamangala University of Technology Rattanakosin	5	1.4
Participation in Environmental or Sustainability-related Courses	No	102	29.4
	Yes	245	70.6
Participation in Environmental Groups or Volunteer Activities	No	87	25.1
	Yes	260	74.9
Gender	Male	157	45.2

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	Female	190	54.8
Age	18	57	16.4
	19	67	19.3
	20	72	20.7
	21	63	18.2
	22	23	6.6
	23	16	4.6
	24	27	7.8
	25	14	4.0
	26	8	2.3
Academic Year	Freshman	63	18.2
	Sophomore	73	21.0
	Junior	75	21.6
	Senior	73	21.0
	Graduate Student	63	18.2
Nationality	Thailand	139	40.1
	China	208	59.9
Major Type	Science/Engineering	84	24.2
	Business	92	26.5
	Sports/Arts	32	9.2
	Humanities	91	26.2
	Medicine	48	13.8
Are you familiar with carbon reduction behaviors?	A. Very familiar with it	89	25.6
	B. Have a good understanding of it	158	45.5
	C. I've heard of it, but I don't know the specifics.	54	15.6
	D. Never heard of it before	46	13.3
What are the main channels for learning about carbon emission reduction efforts? (Multiple selections allowed)	A. School Curriculum/Classroom Learning (Reading, Textbooks, Teacher Lectures)	188	19.5%
	B. Campus Publicity/Regulations (Posters, Notices, Waste Sorting and Energy Saving Tips, etc.)	180	18.7%
	C. Social Media/Short Video Platforms (e.g., Facebook/Instagram/TikTok, etc.)	83	8.6%
	D.Forums/Communities/Online Communities (e.g., Reddit, Line Groups, School	163	16.9%

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	Community, etc.)		
	E. Environmental Protection Clubs/Volunteer Activities/Campus Greening Activities	172	17.8%
	F. Communication with Family/Friends/Peers	83	8.6%
	G. News Media/Government or Institutional Publicity	96	9.9%

4.2 Descriptive Statistics of Research Variables

Descriptive statistics were calculated for the five research variables using a seven-point Likert scale. As shown in Table 4.2, the mean scores ranged from 4.257 to 4.456, and all values were above the scale midpoint of 4. This indicates that respondents generally demonstrated positive environmental attitudes, perceived social support, perceived behavioral control, collective identity, and actual carbon reduction behavior.

Pro-environmental attitude had the highest mean score (M = 4.456, SD = 1.330), suggesting that respondents generally considered carbon reduction meaningful and beneficial. Perceived green behavioral control ranked second (M = 4.356, SD = 1.315), indicating that students generally believed that they had the ability and conditions to perform low-carbon behavior.

Collective identity had the lowest mean score (M = 4.257, SD = 1.280). Although this value remained above the midpoint, it suggests that respondents' group-based identification with carbon reduction was weaker than their individual environmental attitudes. Carbon reduction behavior recorded a mean of 4.323, indicating a moderate-to-positive level of actual low-carbon action.

Table 4.2 Descriptive Statistics of Measurement Items and Dimensions

Dimension	Item	Item Mean	Item Std. Deviation	Dimension Average Mean	Average Std. Deviation
Pro-environmental Attitude (ATT)	ATT1	4.401	1.646	4.456	1.330
	ATT2	4.524	1.626		
	ATT3	4.409	1.597		
	ATT4	4.519	1.601		
	ATT5	4.380	1.744		
	ATT6	4.504	1.661		
Subjective Norms (SN)	SN1	4.245	1.678	4.312	1.336
	SN2	4.334	1.699		
	SN3	4.320	1.545		
	SN4	4.300	1.630		

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	SN5	4.329	1.702		
	SN6	4.346	1.647		
	PBC1	4.392	1.621		
	PBC2	4.380	1.625		
Perceived Green Behavioral Control	PBC3	4.323	1.571	4.356	1.315
	PBC4	4.360	1.683		
	PBC5	4.329	1.631		
	PBC6	4.352	1.610		
	CI1	4.262	1.625		
	CI2	4.280	1.543		
Collective Identity (CI)	CI3	4.228	1.601	4.257	1.280
	CI4	4.173	1.676		
	CI5	4.349	1.651		
	CI6	4.251	1.596		
	CRB1	4.435	1.607		
	CRB2	4.317	1.635		
Carbon Reduction Behavior (CRB)	CRB3	4.176	1.588	4.323	1.268
	CRB4	4.329	1.540		
	CRB5	4.380	1.571		
	CRB6	4.300	1.638		

4.3 Reliability and Validity Analysis

4.3.1 Reliability Analysis

Cronbach's alpha was used to assess the internal consistency of the measurement scales. As shown in Table 4.3, the alpha values of the five constructs ranged from 0.881 to 0.895, while the overall scale achieved an alpha value of 0.924. These coefficients indicate strong internal consistency among the measurement items (Tavakol & Dennick, 2011).

Table 4.3 Reliability Results

Construct	Number of items	Cronbach's alpha
Pro-environmental attitude	6	0.894
Subjective norm	6	0.895
Perceived green behavioral control	6	0.895
Collective identity	6	0.881
Carbon reduction behavior	6	0.883
Overall scale	30	0.924

These results demonstrate that the questionnaire had satisfactory internal consistency and was appropriate for subsequent factor analysis and structural equation modeling.

4.3.2 KMO and Bartlett's Test

The Kaiser–Meyer–Olkin value was 0.926, exceeding the recommended threshold of 0.90. Bartlett's test of sphericity was also statistically

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significant, χ^2 = 5,635.064, df = 435, p < .001. Therefore, the correlations among the measurement items were sufficient for factor analysis.

Table 4.4 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.926
Bartlett's Test of Sphericity	Approx. Chi-Square	5635.064
	df	435
	Sig.	0.000

4.3.3 Confirmatory Factor Analysis

Confirmatory factor analysis was conducted to assess convergent and discriminant validity. The standardized factor loadings ranged from 0.723 to 0.805. Composite reliability values ranged from 0.882 to 0.895, while AVE values ranged from 0.554 to 0.588. Taken together, these results provide evidence of satisfactory construct reliability and convergent validity (Cheung et al., 2024; Fornell & Larcker, 1981).

Table 4.5 Convergent Validity Results

Construct	Loading range	CR	AVE
ATT	0.758–0.772	0.894	0.584
SN	0.723–0.805	0.895	0.586
PBC	0.746–0.778	0.895	0.588
CI	0.725–0.760	0.882	0.554
CRB	0.728–0.778	0.883	0.557

Discriminant validity was assessed using the Fornell–Larcker criterion. The square roots of AVE ranged from 0.744 to 0.767 and were greater than the inter-construct correlations, which ranged from 0.369 to 0.457. These results confirm that the five constructs were statistically distinct.

4.4 Structural Model and Direct-Effect Testing

Structural equation modeling was conducted after the measurement model demonstrated satisfactory reliability and validity. The structural model showed good overall fit, as presented in Table 4.6.

Table 4.6 Structural Model Fit

Fit Index	Criterion	Value
$\chi 2$	-	453.268
df	-	395
$\chi 2$/df	<3	1.148
GFI	>0.9	0.921
RMSEA	<0.10	0.021
CFI	>0.9	0.989
NFI	>0.9	0.922
RFI	>0.9	0.914
TLI	>0.9	0.988
AGFI	>0.9	0.907
IFI	>0.9	0.989

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The χ^2/df value was 1.148, while GFI, AGFI, CFI, TLI, NFI, RFI, and IFI all exceeded 0.90. RMSEA was 0.021. Considering these fit indices jointly, the proposed structural model demonstrated a satisfactory fit to the observed data (Iacobucci, 2010).

The direct-effect results showed that all four predictors had significant positive effects on carbon reduction behavior. Collective identity produced the strongest direct effect (β = 0.183, p = .005), followed closely by pro-environmental attitude (β = 0.182, p = .007) and subjective norm (β = 0.178, p = .007). Perceived green behavioral control also had a significant effect, although its coefficient was comparatively smaller (β = 0.140, p = .035).

Table 4.7 Direct-Effect and Hypothesis-Testing Results

Hypothesis	Path	Standardized coefficient	p-value	Result
H1a	ATT → CRB	0.182	.007	Supported
H1b	SN → CRB	0.178	.007	Supported
H1c	PBC → CRB	0.140	.035	Supported
H2	CI → CRB	0.183	.005	Supported

The significant ATT → CRB relationship indicates that students with more favorable evaluations of carbon reduction were more likely to perform low-carbon actions. The significant SN → CRB relationship shows that support and expectations from important others contributed to students' behavior. The significant PBC → CRB relationship suggests that perceived ability and behavioral feasibility also encouraged carbon reduction. Most importantly, collective identity showed the strongest direct effect, demonstrating that students were more likely to act when carbon reduction was understood as part of their shared group values and responsibilities.

4.5 Bootstrap Mediation Analysis

The mediating role of collective identity was examined using 5,000 Bootstrap resamples and 95% confidence intervals. An indirect effect was considered significant when its confidence interval did not include zero (Cheung, 2009). As shown in Table 4.8, none of the confidence intervals included zero; therefore, all three mediation hypotheses were supported.

Table 4.8 Bootstrap Mediation Analysis Results of Collective Identity

Hypothesis	Indirect path	Indirect effect	95% confidence interval	p-value	Result
H3a	ATT → CI → CRB	0.044	[0.013, 0.096]	.002	Supported
H3b	SN → CI → CRB	0.043	[0.014, 0.091]	.002	Supported
H3c	PBC → CI → CRB	0.029	[0.005, 0.073]	.016	Supported

The indirect effect of pro-environmental attitude was the strongest at 0.044. Its confidence interval ranged from 0.013 to 0.096 and did not contain zero. The direct effect remained statistically significant;

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therefore, collective identity partially mediated the relationship between pro-environmental attitude and carbon reduction behavior.

The indirect effect of subjective norm was 0.043, with a confidence interval from 0.014 to 0.091. Since both its direct and indirect effects were significant, collective identity also partially mediated this relationship.

The indirect effect of perceived green behavioral control was 0.029, with a confidence interval from 0.005 to 0.073. In the Bootstrap analysis, its direct-effect confidence interval included zero, indicating that perceived behavioral control primarily influenced carbon reduction behavior through collective identity. Thus, collective identity transmitted the effect of perceived behavioral control more fully than the effects of attitude and subjective norm.

These findings demonstrate that collective identity serves as an important psychological bridge between individual cognition and actual low-carbon action. Positive attitudes, social expectations, and perceived behavioral capacity were more likely to result in carbon reduction behavior when students internalized low-carbon practices as shared group values.

4.6 Summary of Hypothesis Testing

Table 4.9 Summary of Hypothesis Testin

Hypothesis	Proposed relationship	Result
H1a	Behavioral attitude positively affects carbon reduction behavior	Supported
H1b	Subjective norm positively affects carbon reduction behavior	Supported
H1c	Perceived behavioral control positively affects carbon reduction behavior	Supported
H2	Collective identity positively affects carbon reduction behavior	Supported
H3a	Collective identity mediates ATT → CRB	Supported
H3b	Collective identity mediates SN → CRB	Supported
H3c	Collective identity mediates PBC → CRB	Supported

Overall, all proposed hypotheses were supported. The results confirm that carbon reduction behavior is influenced by both individual-level psychological factors and group-based identity mechanisms. Among the direct predictors, collective identity had the strongest effect. It also significantly mediated all three relationships between the planned behavior variables and carbon reduction behavior.

5. Conclusion, Discussion, and Recommendations

5.1 Conclusion

This study examined the formation of carbon reduction behavior among university students in Thailand by integrating the Theory of Planned Behavior and Social Identity Theory. Behavioral attitude, subjective norm, and perceived behavioral control were

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treated as individual-level psychological factors, while collective identity was introduced as a group-based mediating mechanism.

The results showed that behavioral attitude, subjective norm, perceived behavioral control, and collective identity all had significant positive effects on carbon reduction behavior. Among these variables, collective identity had the strongest direct effect. This finding indicates that students are more likely to engage in carbon reduction behavior when they regard low-carbon action as part of the shared values and responsibilities of the university student community.

The Bootstrap results further showed that collective identity significantly mediated the relationships between behavioral attitude, subjective norm, perceived behavioral control, and carbon reduction behavior. Therefore, carbon reduction behavior is shaped not only by personal evaluation, social expectations, and perceived ability, but also by the extent to which students internalize low-carbon behavior as part of their group identity.

Overall, the findings support all proposed hypotheses and demonstrate that collective identity serves as an important psychological bridge between individual cognition and actual low-carbon action.

5.2 Discussion

5.2.1 Behavioral Attitude and Carbon Reduction Behavior

The results showed that behavioral attitude had a significant positive effect on carbon reduction behavior. Students who believed that low-carbon behavior was beneficial, meaningful, and socially responsible were more likely to practice energy conservation, green consumption, and low-carbon transportation.

This finding is consistent with the Theory of Planned Behavior, which proposes that favorable behavioral evaluations increase the likelihood of performing the corresponding behavior (Ajzen, 1991). It also supports previous evidence that positive environmental attitudes contribute to pro-environmental action (Bamberg & Möser, 2007; Steg & Vlek, 2009).

However, the effect of attitude was not dominant. This suggests that recognizing the value of carbon reduction alone may be insufficient to ensure stable action. Students may still require social encouragement, practical conditions, and identity-based motivation.

5.2.2 Subjective Norm and Carbon Reduction Behavior

Subjective norm had a significant positive effect on carbon reduction behavior. This result indicates that expectations and support from classmates, friends, teachers, families, and universities influence students' low-carbon practices.

The finding is consistent with previous studies showing that social norms shape environmental behavior by communicating what is socially expected and approved (Cialdini et al., 1990; Farrow et al., 2017). In the university context, students are constantly exposed to peer behavior and institutional messages. When important social groups support carbon reduction, students are more likely to act consistently with these expectations.

This result also highlights the

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importance of the campus social environment. Low-carbon behavior is more likely to develop when it is visible, encouraged, and socially recognized.

5.2.3 Perceived Behavioral Control and Carbon Reduction Behavior

Perceived behavioral control also had a significant positive effect on carbon reduction behavior. Students who believed that they had sufficient knowledge, resources, opportunities, and ability were more likely to perform low-carbon actions.

This finding supports Ajzen's (1991) argument that behavior becomes more likely when individuals consider it feasible and controllable. For university students, practical factors such as access to public transportation, recycling facilities, affordable green products, and energy-saving infrastructure may determine whether environmental beliefs can be translated into action.

Compared with the other direct effects, perceived behavioral control had a relatively weaker coefficient. Nevertheless, its significant indirect effect through collective identity suggests that perceived feasibility may strengthen students' belief that low-carbon behavior can become a realistic and shared group practice.

5.2.4 Collective Identity and Carbon Reduction Behavior

Collective identity had the strongest direct effect on carbon reduction behavior. This result demonstrates that students are more likely to maintain low-carbon practices when they perceive such behavior as part of the shared identity and responsibility of their group.

The finding supports Social Identity Theory, which proposes that individuals partly define themselves through group membership and tend to align their behavior with the values and norms of salient identity groups (Hornsey, 2008). It is also consistent with environmental identity research showing that group identification can promote pro-environmental action by linking environmental responsibility with the meaning of "who we are" (Fielding & Hornsey, 2016; Fritsche et al., 2018).

This result extends the individual-level explanation of the Theory of Planned Behavior. It suggests that carbon reduction behavior becomes more stable when it is transformed from "a behavior I personally support" into "a behavior that people like us should perform."

5.2.5 Mediating Role of Collective Identity

The Bootstrap results confirmed that collective identity mediated all three relationships between the planned behavior variables and carbon reduction behavior.

First, positive behavioral attitude strengthened carbon reduction behavior partly because favorable evaluations encouraged students to accept low-carbon values as part of their group identity. Second, subjective norm influenced behavior partly because external expectations were internalized as shared group responsibilities. Third, perceived behavioral control influenced behavior through collective identity because feasible low-carbon practices were more likely to be regarded as realistic group standards.

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These findings indicate that collective identity is not merely another direct predictor. It explains how individual cognition and external social influence are converted into more stable action. Therefore, the integration of the Theory of Planned Behavior and Social Identity Theory provides a more complete explanation of carbon reduction behavior than either theory alone.

5.3 Answers to the Research Questions

5.3.1 Answer to RQ1

RQ1 asked how behavioral attitude, subjective norm, and perceived behavioral control influence the carbon reduction behavior of university students in Thailand.

The results showed that all three variables had significant positive effects on carbon reduction behavior. Behavioral attitude had a standardized effect of $\beta = 0.182$, subjective norm had an effect of $\beta = 0.178$, and perceived behavioral control had an effect of $\beta = 0.140$.

These results indicate that students are more likely to engage in carbon reduction behavior when they regard it positively, perceive support from important others, and believe that they have the ability and conditions to perform it.

5.3.2 Answer to RQ2

RQ2 asked what role collective identity plays in shaping carbon reduction behavior.

The results showed that collective identity had a significant positive effect on carbon reduction behavior, with $\beta = 0.183$. It was the strongest direct predictor among the variables included in the model.

This means that students who regard carbon reduction as part of the shared values, responsibilities, and identity of the university community are more likely to perform actual low-carbon behavior.

5.3.3 Answer to RQ3

RQ3 asked how collective identity explains the transformation of behavioral attitude, subjective norm, and perceived behavioral control into carbon reduction behavior.

The Bootstrap results showed that collective identity significantly mediated all three relationships. The indirect effects were 0.044 for behavioral attitude, 0.043 for subjective norm, and 0.029 for perceived behavioral control. None of the 95% confidence intervals included zero.

Therefore, collective identity functions as a psychological bridge. It helps transform personal evaluation, social expectations, and perceived ability into actual low-carbon action by internalizing carbon reduction as a shared group value.

5.4 Theoretical Implications

This study provides three theoretical contributions.

First, it extends the Theory of Planned Behavior by incorporating collective identity into the explanation of actual carbon reduction behavior. The findings show that individual-level psychological factors remain important, but their effects can be strengthened through group identification.

Second, the study links the Theory of Planned Behavior with Social Identity Theory. The integrated model explains both the cognitive foundations of

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behavior and the identity-based process through which these foundations become internalized.

Third, the study provides empirical evidence from the context of universities in Thailand. The results show that group-based psychological processes are particularly relevant in a campus environment characterized by frequent peer interaction, shared activities, and institutional influence.

5.5 Practical Recommendations

Universities should not rely solely on environmental knowledge campaigns. Although education can improve attitudes, stable carbon reduction behavior also requires social support, practical opportunities, and collective identification.

First, universities should strengthen low-carbon campus identity by presenting carbon reduction as a shared student responsibility. Sustainability messages can emphasize collective expressions such as “our campus” and “our shared responsibility.”

Second, universities should use peer influence more effectively. Student leaders, environmental clubs, and volunteer groups can demonstrate low-carbon practices and create visible behavioral norms.

Third, universities should improve the practical conditions for carbon reduction. Convenient public transportation, recycling facilities, energy-saving equipment, and accessible green products can increase students’ perceived behavioral control.

Finally, low-carbon activities should encourage continuous participation rather than one-time involvement. Green challenges, campus competitions, recognition programs, and group-based projects may help transform temporary participation into stable habits.

5.6 Limitations and Future Research

This study has several limitations. First, the cross-sectional design measured variables at one point in time and therefore cannot establish long-term causal relationships. Future research may use longitudinal or experimental designs to examine how collective identity and carbon reduction behavior change over time.

Second, convenience sampling was used, and the sample included university students from selected institutions in Thailand. Therefore, the findings may not be fully generalizable to all university students or other social groups. Future studies may apply probability sampling and include participants from different regions and countries.

Third, the data were collected through self-reported questionnaires. Respondents may have overreported socially desirable environmental behavior. Future studies may combine questionnaires with behavioral observations, electricity-use records, transportation data, or other objective indicators.

Fourth, this study focused on behavioral attitude, subjective norm, perceived behavioral control, and collective identity. Other variables, such as environmental knowledge, personal values, collective efficacy, institutional support, and environmental concern, may also influence carbon reduction behavior and should be examined in

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future research.

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